NATURAL SCIENCE:

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NOTES AND COMMENTS.

The British Association.

BRITISH Science is again preparing for its annual festival, which will be inaugurated by Professor Burdon Sanderson, at Nottingham, on the evening of September 13. There are, as usual, many malcontents who disparagingly remark that the association has "had its day"; and we know a number of eminent biologists and geologists who have declared that this year their vacation shall not be interrupted by attendance at committees and in scientific meeting rooms. There is, however, every prospect that the forthcoming meeting will be no less a success than most of its predecessors; and the organising committees have done well in arranging a goodly number of interesting discussions. We note, moreover, that the President of the section for Geology (Mr. Teall) announces his Address to be not a mere general summary of recent progress, but to deal with no less fundamental a subject than the Doctrine of Uniformitarianism, as viewed from his own special domain of research.

If these discussions of wide themes were more generally encouraged than they are, and if the innumerable, desultory, technical papers, often only of local interest, were absolutely refused, the Sectional Meetings would be much more appreciated than is the case at present, and the Report would be relieved of a burden of brief "abstracts" that are of little use to anyone. However much the enthusiast may sneer at the "picnic element" in the gathering, it can never be reduced until narrow specialists are prevented from inflicting the details of their work upon the Sections. The British Association Meeting is a great reunion of amateurs and patrons of Science rather than of professed devotees, and it forms one of the most important sources of revenue upon which the latter can depend for assistance in their investigations. The programme ought, therefore, to be adapted,

as far as possible, to a general scientific assembly, and there is then no fear that this great meeting will lose any of its long-sustained interest and importance in the intellectual life of the nation.

TRILOBITES.

CONSIDERING the abundance of the familiar Palæozoic fossils named Trilobites, it is singular how little is known of their appendages. Twelve years ago the researches of Mr. C. D. Walcott showed that the ventral side of the body was covered with a hardened arch over each segment bearing a pair of limbs, while the head was provided with four pairs of appendages, acting as jaws at the base, as in the modern King Crabs.

More than 20 years ago, Dr. Henry Woodward also discovered a kind of palpus attached to an inferior head-plate; but conditions of fossilisation more satisfactory than any of those under which trilobites have hitherto been met with can alone permit much advance is our knowledge of the subject.

A stratum in the Hudson River shales, near Rome, New York State, it is interesting to note, has yielded materials for the first step in this advance. The discovery of a number of specimens of

HEAD OF TRILOBITE SHOWING ANTENNÆ.

Triarthrus becki by Mr. W. S. Valiant, enables Mr. W. D. Matthew to contribute an important paper on the subject to the current issue of the *Amer. Journ. Sci.* (ser. 3, vol. xlvi., pp. 121–125, pl. i.); and it now appears that not only had the trilobites the appendages already observed, but also a well-developed pair of antennæ. We reproduce a figure of the best specimen above. The antennæ are composed of a great number of joints, each of which is conical, about half as long as wide, and smallest at the base. They seem to have been of a structure less firm and thick than the substance of the carapace; and just over the spot where they come out, the anterior margin of the

head-shield is arched slightly upwards, apparently to afford space for their play to and fro. On the side of the same head there are also some impressions that may indicate the gills, though it is equally probable they are merely hairs on a narrow limb, serving as mouth-organs.

Trilobites are also discussed in the same journal (pp. 142–147, pl. ii.) by Dr. C. E. Beecher, who follows the work of Barrande in attempting to interpret the larvæ. Here, again, the fine character of the sediments in which the fossils are embedded (Lower Helderberg, near Albany, N.Y.) favours the investigation. Moreover, the facts are of especial interest in this case, because all the trilobites belong to highly ornamented and specialised genera. Some beautiful figures are given with detailed descriptions, and Dr. Beecher concludes by trying to generalise in reference to the normal life-history of a trilobite. The results are too technical for recapitulation here, but they show that before long zoologists will be able much more satisfactorily than hitherto to discuss the reference of these characteristic Palæozoic organisms to Crustacea or Arachnids.

Fishes at High Temperatures.

Dr. Lawrence Hamilton forwards some interesting statistics he has collected in reference to the existence of fishes in water of a high temperature. Some of the cases are very striking. Spallanzani, it appears, observed river carp living at a temperature of 106° F., and exhibiting no signs of uneasiness, though at 109° they began to struggle, and died at 116° F. Dr. John Davy (1835) showed that the Bonito had a temperature of 99°, while the water of the Mediterranean, in which it was, had only a temperature of 80°. Saussure stated that he found eels in the hot springs of Aise, in Savoy, at a temperature of 113° F. In 1882, Dr. Davy found that water at 85° F. killed trout by convulsions. A trout and a minnow were put in water at 70° at night, which by the next morning had sunk to 67°, when the trout was dead, though the minnow had not suffered. A salmon parr at 80° became convulsed and torpid, dying at 84°. Several fishes were deposited in water at 53° F.; the temperature of the water was gradually raised, and none showed signs of failing vitality till the thermometer rose to 82°, when the perch became prostrated, roach succumbed at 82½°, salmon at 83°, minnow at 85°, gudgeon at 85½°, dace at 86°, tench at 88°, and carp at 91°. Brandy restored all the fishes except the dace, which died.

In India, fishes at noon-day in their natural water remain in health at 92°; at 4 p.m., 86°; and at 6 p.m., 82°. Günther states that Cyprinodonts live in briny springs even at a temperature of 91° F.

Sir Emerson Tennent collected the following observations, which seem to require further proof or verification:—

In the hot springs of Ceylon, living carp, *Nuria thermoicus*, at

114° F.; members of the perch family, the *Apogon thermalis*, and the *Ambassis thermalis*, in water at 115° F.; a roach, *Leuciscus thermalis*, at 112° F.

In a hot spring at Pooree (in the province of Bengal), with the thermometer in the water standing at 112° F., carnivorous fishes have been discovered, which would indicate that these must have found and fed on living prey at the same high temperature. Further accounts, moreover, declare that in hot springs in Barbary, in North Africa, living fishes have been taken in water at 172°, while in Manila (one of the Philippine Islands) in water marking 187° F. While travelling in South America, Humboldt and Koupland stated that they saw fishes thrown up alive from a volcano in water at 210° F., but this is, of course, an absurdity which nowadays, it is to be hoped, no one will believe.

THE DWINDLING OF LIMESTONES.

IN an article on the Dwindling and Disappearance of Limestones (*Quart. Journ. Geol. Soc.*, vol. xlix., pp. 372–384, pl. xviii., Aug., 1893), Mr. Frank Rutley discusses the question, which he has himself raised, of the possible dissolution of limestones that were formed during the earlier periods of the earth's history. That limestone is dissolved by the action of acidulated waters, and that caverns, "pipes," and other features are formed in the rocks, are facts familiar enough. The author, however, contends that if unlimited time be conceded, there seems no reason why very thick beds of limestone should not wholly disappear; at all events, he thinks that thin ones may easily do so, and thereby certain pages in the life-history of particular localities may be lost for ever. Unfortunately for his argument, the author is unable to bring forward any special evidence in support of it. The Durness Limestone of Cambrian age must be of considerable thickness, and yet it has survived many vicissitudes. The Carboniferous Limestone over large areas, though in places riddled with caverns, presents in mass its full thickness; it passes by alternations of limestone and shale into the beds above and below, while the masses of the *insoluble* strata above and below are more extensively wasted away. Statistics of the amount of solid matter carried away by rivers and streams prove how large an amount of limestone is dissolved, but, except in the case of thermal springs, the loss of material is not very deep-seated.

Attention is drawn to the nodular character of some limestones, and the author very properly points out that in some cases a bed of jointed limestone may become weathered into isolated nodules. He proposes to call these nodules *residual*, as distinct from concretions or segregation-nodules. These residual nodules occur, so far as we know, only where the strata come near the surface; but they serve to confirm one of the author's conclusions, namely, "That bands of limestone-nodules may, in certain cases, represent what were

originally *beds* of limestone." Under similar conditions, that is to say, near the surface, "bands or nodules of chert may represent all that remains of what were once beds of cherty limestone."

Whether the comparatively thin limestones in some of the older formations were originally much thicker, is a subject to which attention may profitably be directed.

Bibliography of Botany.

Mr. J. C. Bay, of the Missouri Botanical Garden, submits a scheme in the July issue of the *Botanical Gazette* for the production of a yearly bibliography of American botany. It will be on the lines of Just's well-known *Jahresbericht* which, Mr. Bay complains, pays little attention to American literature, and should give, (*a*) a list of papers and works in every department of botany, *absolutely* complete; (*b*) a review of each of these papers and works, short and perfectly *objective*. A third point is that, as the importance of such a work would be international, it should be published and sold separately and not assimilated by any report or periodical, as in the latter case it would be inaccessible to many botanists. The Smithsonian publications are referred to as so very expensive as hardly to be ever seen in private libraries in other countries. The publishing should therefore, as far as business management goes, be in the hands of a publisher.

The work should be undertaken by a committee among the members of which the editor should distribute the reprints of the papers received from botanical authors. A classification under fifteen heads is suggested, and Mr. Bay is willing to look after subjects falling under three of these. The whole work "could appear in July," *i.e.*, only six months after date; truly an admirable feature. We wish the scheme success. If a publisher can be found to do the thing well and satisfy himself on the score of finance, perhaps some English brother will be courageous enough to follow the example in our own country. At present, we have only Just, and of this the concluding part, *i.e.*, *the part containing the index* of the volume for 1890 bears the date 1893. The *Annals of Botany* started in 1887 with a record of current literature, but this ceased with the fourth volume, under the plea that space was too valuable! The Linnean Society might do it, but it would have to wake up.

The *Kew Bulletin of Miscellaneous Information* is beginning to justify its title in a novel and remarkable way. In the July number we have a list of the principal guests at a garden party given by the First Commissioner of Works on the lawn and reserve part of the Royal Gardens, adjoining Kew Palace. We learn that "more than a thousand people thronged the grounds," and that the "host and hostess, accompanied by about 200 guests, arrived at Kew by special

steamers from the House of Commons Pier." Surely such details and records might be left to the *Morning Post* and the Society journals, which are not published by "Her Majesty's Stationery Office." The "miscellaneous information" is expected to have reference to economic botany, and not to the festivities of "Society." The Director of Kew is commonly supposed to have exhibited a courageous independence of the wishes of exalted personages, who have presumed too much in their visits to the Royal Gardens, and one would have expected him not to tolerate such doings at all, rather than to chronicle their occurrence in the *Bulletin*. Even if this account be followed by a more extended list of less eminent visitors on the August Bank Holiday, with a report of their innocent recreations, it will only show the Director's wide view of the limits of "Society." The one thing would be as unjustifiable as the other, in an official publication, which may, or may not, by its sale repay the Treasury for the cost of its production.

IT might perhaps conduce to promptness if the editor of the *Kew Bulletin* read NATURAL SCIENCE. In last year's July number (vol. i., p. 327) we gave an abstract of a Colonial Report on the Aldabra Islands, a small group to the north-east of Madagascar; while the *Kew Bulletin* for July of this year supplies "some recent information about this little-known group," in great part consisting of a letter from the Administrator of the Seychelles, dated June 13, 1892, which merely repeats some of the facts noticed by us a year ago. About a third of the article is occupied with a letter from Dr. W. L. Abbott, an American, who visited the islands at the end of last year and collected specimens of most of the native plants, which were sent to Kew, but have, unfortunately, miscarried. His short note adds but little to our knowledge of the vegetation already gained from the account given by the lessee, Mr. Spurs, in the above-mentioned Colonial report. Dr. Abbott says: "There do not seem to be more than 35 indigenous species," while Mr. Spurs mentions 30. The only trees now in Aldabra are Casuarinas and Mangroves, but decaying stumps of "Porché" and "Rose-wood" show that these formerly grew to a considerable size, though now only small ones exist. Mr. Spurs referred to the destruction of the large trees, which he considers partly due to the hurricane of 1889.

Apropos of the *Bulletin*, why is it necessary to insert so many official letters spread out into numbered paragraphs like a child's lesson-book? If the information, which is often of interest, were boiled down and the numerous salutations, etc., omitted, the publication would be more readable, and the recent doubling of the price rendered unnecessary.

DR. OTTO KUNTZE communicates some "Remarks on the Genoa Congress" to the July number of the Californian journal, *Erythea*.

Dr. Kuntze finding himself unable to prepare in time the elaborate critique on questions of nomenclature which he had promised to lay before the International Committee at the end of June, offers to Americans, through the pages of *Erythea*, a brief syllabus of leading exceptions to be taken to the doings of the Genoa Congress last year. Its resolutions, he says, must fail to obtain the force of international laws by reason of—

I. Four illegalities in its organisation and methods of procedure.

II. Three absurdities, by which the resolutions which they affect become illegal and impracticable.

III. *Violatio juris quæsiti.*

Is *Erythea* on the wane? The last three numbers (May to July) feel very thin, containing only 16, 20, and 16 pages respectively, whereas the journal started with 28 last January, and contained 24 in February and March, while the number rose to 32 in April.

Two alpine anemones, *Anemone alpina* and *A. sulphurea*, are the subject of a notice by M. F. Prévost Ritter, in the *Bulletin de l'Herbier Boissier*, no. 6. The second of these two is generally admitted to be only a colour form of the first, depending on the chemical composition of the soil. H. Christ, in his work on the origin of the Swiss flora, cites them as a most remarkable instance of the influence of the soil on the distribution of plants. In the Alps, he says, the white-flowered form (*A. alpina*) occurs exclusively on the chalk, while the one with a sulphur-yellow blossom is only found on clayey and sandy soil. So sharp is the limitation, that where the two soils meet the two varieties faithfully follow the line of division; while where the transition is gradual, the flower passes by a series of intermediate shades from white to yellow. In order to find out, if possible, the cause of this phenomenon, M. Ritter has, since 1886, been cultivating the seedlings of the two forms in sandy and chalky soils. He finds that, while *Anemone alpina* prefers the chalk, but will grow in sand, *A. sulphurea* will only grow in the latter. He also concludes from differences in the shape of the cotyledons, that the yellow-flowered plant must be considered not as a mere form or variety, but as a distinct species. He says, and his figures bear him out, that the seed-leaves of *A. sulphurea* are larger, and have a shorter and more rounded tip, while those of the *A. alpina* are narrower, oblong, and pointed.

In the *Journal de Botanique* for July 1 and 16, M. Hua describes as a new genus a plant from West Tropical Africa, in which the flowers are borne along the midrib on the back of the leaf. This anomalous position of the flowers is only of rare occurrence, appearing in a few almost or quite monotypic genera, such as the

Japanese *Helwingia* of the Araliaceæ, the saxifragaceous *Phyllonoma* from the New World, and *Polycardia* (Celastrineæ) from Madagascar. The common lime recalls, in a small degree, the same phenomenon, the stalk of the inflorescence adhering to the lower part of the bract and appearing to spring from the middle of that organ. Tropical West Africa boasted already two genera with epiphyllous flowers both belonging to the family Bixineæ, and *Mocquerysia*, the new one established by M. Hua (named after its discoverer, M. Mocquerys) resembles these in some points, and is placed by its author in the same natural order.

IF ordinary placental mammals have evolved from pouched animals like the modern marsupials, rudiments of the pouch ought certainly to be recognisable in some of them. Dr. H. Klaatsch (*Morphol. Jahrb.*, vol. xx., pp. 276–288, 1893), has just made the interesting announcement that such rudiments can actually be observed in most placentals. Something of the kind has already been found in the lemurs, and one author has supposed that rudiments of the pouch can also be detected in the sheep. The detailed account of Dr. Klaatsch's extension of the evidence will be awaited with interest.

M. ADRIEN DOLLFUS provides a first supplement to his Catalogue of the Terrestrial Isopoda of Spain in the xxii. vol. of *Anal. Soc. Españ. Hist. Nat.*, 1893. The same mail brings to us a second paper of his on this group of animals from the Canaries, which adds to our previous knowledge obtained through him in a paper dealing with specimens from the Azores, Madeira, and the Canaries (*Bull. Soc. Zool. France*, 1889, p. 12). Seven new forms are described, and the essential portions figured, in *Mém. Soc. Zool. France*, vol. vi., 1893, pp. 46–56. It is quite possible that diligent search in England might reveal many interesting points in distribution of the wood-lice, and even result in the discovery of new forms.

APROPOS of the "Plague of Wasps" in the South of England, a correspondent suggests our calling in the assistance of the toad. "A toad will," he writes, "sit for some time quite comfortably by a wasps' nest (in the evening, of course) and pick up the belated wanderers as they return home. The sting is absolutely disregarded, and not the faintest attention is paid to the warning colours of the wasp. An evening or two since I persuaded a large fat toad to take up a position actually blocking up the entrance to a nest. He waited there for a few minutes, during which he caught several wasps and made unsuccessful shots with his long tongue at others." One might, perhaps, instal a circle of toads round the orifice of the nest, and then, after stirring it up with a long stick, depart to give free play to the toads and wasps to fight it out between them.

A CORRESPONDENT remarks that in our review of Professor Alfred Newton's "Dictionary of Birds" last month (p. 146), we overlooked the fact that the author had descended to a particularly low level in his criticisms on others. "The remarks on p. 133 regarding the Timeliidæ can only be described as the language of the gutter, and should hardly emanate from a member of one of our old Universities, a person of culture, and, we had hoped, a gentleman. But they impress upon us more than ever the old adage, 'Manners makyth man.'" We are not concerned here with the author's convenient neglect of many well-known publications—that will reflect upon himself in due season.

DR. J. W. GREGORY arrived safely at Mombasa, East Africa, on August 19, and he may be expected in England before the end of September.

ACCORDING to the London *Daily Chronicle*, two members of the Geological Survey of Canada have left this summer for the exploration of Labrador. The exploring party will be absent from civilisation for two years; they will traverse the interior of Labrador from south to north, as well as from east to west, especially visiting the great Lake Mastassini, and the cataract of the Hamilton River, concerning the size and nature of which such fabulous tales have been told. They will winter with the Eskimos on Ungava Bay, where only four of the twenty-four hours of the winter day are daylight. They expect to return to Canada from Hamilton inlet, *viâ* a Hudson's Bay Company's steamer trading with England.

M. MATHIEU MEIG contributes to the *Feuille des Jeunes Naturalistes*, a paper of Excursions in the district of the Lower Carboniferous of Alsace. This is apparently one of a series, and deals with Bourbach-le-Haut, Massevaux, Rothhütel, Rossberg, Stauffen, Steinby and Hundsrücken. M. Meig commences with a useful bibliography of papers on the district, gives notes on the general divisions and composition of the Carboniferous beds of Alsace, and discusses the details in the form of an itinerary.

THE August number of the *Quarterly Journal of the Geological Society* contains an important contribution to the Highland question. Mr. George Barrow has now traced a clear succession in Forfarshire, the comparatively thin strata being repeated by sharp folds, till they form a mass of enormous thickness. The various zones are all highly metamorphosed; but Mr. Barrow shows by analyses and the occurrence of particular minerals, that a certain zone is an altered quartzite, another is an altered limestone, and a third is probably a highly metamorphosed clay. The greater part of this change he

considers to be due to the intrusion of huge sills or laccolites of muscovite-biotite gneiss.

ATTENTION was directed to the Underground Waste of the Land in a former number of NATURAL SCIENCE (vol. ii., p. 124). The subject has also attracted the notice of Professor Lebour. In an article on certain surface features of the Glacial deposits of the Tyne Valley, near Corbridge (*Nat. Hist. Trans. of Northumberland*, etc., vol. xi., part 2, 1893), he states that a notable amount of sand and very fine gravel is continually being discharged from underground, by springs which issue at the junction of the Glacial sands and gravels with the underlying Boulder Clay. He thinks that the bowl-shaped depressions of the surface of the drift gravel and sand of the Tyne Valley—depressions that have the characters of "kettle-holes"—may be due to subterranean erosion. Similarly, features resembling the arched structure of Kames or Eskers may be caused by slipping, due to the eroding action of water below ground.

ANOTHER new British monthly devoted to the science of geology has appeared! We have before us *The Glacialists' Magazine*, vol. i., no. 1, August, 1893. Price 6d. It is edited by Percy F. Kendall, assisted by Warren Upham, C. E. De Rance, and J. Lomas, and its pages are crowded with misprints. Mr. De Rance, who is President of the Glacialists' Association, communicates his address, which was delivered last year, and discusses the geology of the northern Polar regions, concluding that no evidence of former Glacial periods is to be found among the strata. He is, however, scarcely just to the naturalists who accompanied Sir George Nares, when he says it fell to his lot to work up the geological results obtained. The observations were made by Colonel Feilden and others (very competent geologists), while the fossils were identified by Mr. Etheridge. An intrusive mass of Boulder Clay at Bidston, Cheshire, is described by Mr. A. R. Dwerryhouse; and there is a review of Sir Henry Howorth's "Glacial Nightmare" by the Editor. There are also short notes on various subjects, and an account of "Current Glacial Bibliography." The Bibliography, if rendered complete, will no doubt form a valuable record, but otherwise we are inclined to question the advantage of issuing a separate journal on the subject of Glacial Geology. Moreover, we fear that a modest monthly of 29 pages will hardly suffice for the verbosity peculiar to most writers on Glacial Geology.

STILL another American journal relating to geology—the *Bulletin of the Department of Geology, University of California*—has made its appearance. As far as we can judge by the first part, which is all that has reached us, it would, perhaps, be more correctly entitled "Memoirs" than "Bulletin," for it consists of one paper of 59

pages, "The Geology of Carmels Bay," by Andrew C. Lawson, assisted by Juan de la C. Posada. As with most of the American scientific journals, this one is extremely well got up, printing and illustrations both being excellent; but we would like to suggest to our American cousins that the large size, thick paper, and enormously wide margins of all these new journals is a mistake. It is all very well to have one or two large handsome volumes, but when the series mounts to fifty or one hundred, everyone will grumble at the amount of space wasted. This is a matter in which we in the old country are best able to form an opinion, for we have many journals that have reached their fiftieth volume, and all true workers would contemplate with dismay the idea of having to allow double the space for each set.

We regret to learn that the *Midland Naturalist* receives so little support that its publication will be discontinued at the end of the present year.

Two numbers of an "Occasional Paper for Nyasaland" have been printed and published at the Universities Mission Press, at Likoma, an island in Lake Nyasa. They contain notes on Nyasaland Timber, by Mr. William Murray; and memoranda on the occurrence of Garnets and Beryls, by Archdeacon Maples. In future the paper is to be published four times a year, under the name of *The Nyasa News*.

London will shortly rejoice in another club. On and about August 17, a perfect rain of circulars announced to the scientific world that there was no club available "for social intercourse and réunion" of the fellows of the various royal and learned societies. We are glad to observe that so careful a distinction is marked out by the promoters between royal and learned societies. On the front of the circular is a list of "Gentlemen supporting the founding of the Club," whose names can, with patience, be dug out of the perfectly bewildering conglomerate of F.R.S.—F.R.S.G.S.—R.Z.S.I.—Brit. Ass. [*sic*],—etc., etc., in which they are embedded. Then follows the ground for establishing such an arcadia, all for six guineas a year, and lastly, on the back of the circular, comes a series of newspaper-like extracts from letters of the learned, in which the "positive want" is stated with consentaineity, while numerous wailings escape from extra-athenæum clubites. The whole is surmounted by a badge consisting of the American eagle, rather out of drawing, with wings resembling the star-spangled banner, and surrounded by an aureole, in which is hidden "Omnes artes inter se continentur." Colonel W. P. Hodnett, late of the 2nd Dorset (54th) Regiment, as hon. secretary, 63 St. James's Street, will attend to the despairing. *Sic iter ad astra.*

I.

On Epiphytes.

PLANTS are much more directly dependent on the nature of their physical surroundings than are animals, and display a correspondingly greater plasticity of form under varying external conditions. Hence among plants examples of structural harmony with the environment are both striking and numerous; but this malleability in the nature of a plant renders it more difficult to decide when we are dealing with a true instance of adaptation. A leaf exposed to direct sunlight transpires at a greater rate than it would in a damp shaded habitat; and we find that leaves which develop in the sunlight have a structure different to that of leaves of the same species formed in the shade. The leaves developed in the light are structurally so constituted that they transpire less than those formed in the shade, provided that both sets of leaves be exposed to the same conditions; but these peculiarities of structure are not transmitted to the offspring of the respective plants. Here we are not dealing with a case of adaptation—in the narrow sense—but with an instance of the direct effect of the environment on the individual plant. Now this is obviously very different to the case of desert plants, in which the leaves have structural characteristics (succulence, hairs, thick cuticle, sunken stomata, etc.), which are handed down to the offspring grown under any conditions. Here we can see that the leaves are constituted so as to avoid excessive loss of water—they are suited to the dry habitat. But can we at once pronounce this a case of adaptation to the peculiar mode of life on the desert? Decidedly not. Either the ancestor of the desert plant possessed another form, and only changed it gradually as it became a desert plant; or the ancestor possessed these structural peculiarities even before it became a desert plant, and, in fact, only assumed its present mode of life in virtue of these characteristics. In the latter case, correctly speaking, the desert plant is not adapted, though it is suited, to its peculiar mode of life. The environment has not impressed itself on the nature of the plant. That such cases are possible is shown by the fact that plants occupying widely different positions in nature often betray remarkable structural similarities. For example, many Epiphytes, desert-plants, littoral forms, neighbours of mineral springs, alpine plants, and temperate evergreens possess leaves which agree in being

constituted so as to avoid too rapid transpiration (succulence or leathery or hairy nature, strongly developed epidermis with thick cuticle, water-storing tissue) (1). A plant evolved so as to suit one of the above-mentioned environments would incidentally become suited to one of the other modes of life; and it might desert its old habitat and take up the new one for which it had casually become suited. This process has taken place; even now we find plants of which some individuals are epiphytic in jungles, and others are terrestrial alpine plants. In other species, some of the individuals are littoral plants, which do not reappear inland until we reach the mountain tops; and what is true of these individuals is true of certain species of genera. The genus *Casuarina* is a littoral form and a Malayan alpine form, but does not occur in the jungles between these two extremes. So it becomes very difficult to say what characters in a plant are truly adaptive, *i.e.*, acquired with special reference to the present mode of life. And we can only solve the mystery in each case by, on the one hand, studying the physiological nature of the plant; and, on the other, tracing out its past history by means of morphological comparisons with allied forms, and observations on the geographical distribution of it and its relatives. The first person to recognise this was A. F. W. Schimper, whose work on tropical American Epiphytes (2) revolutionised this branch of botany. He introduced a new method of treating biological problems, which should serve as a model for subsequent investigators.

Epiphytes are subjects peculiarly suitable for the study of adaptation; for among them occur all stages from unmodified terrestrial plants right up to forms highly metamorphosed to suit their aërial mode of existence.

For our knowledge on Epiphytes we are almost solely indebted to Schimper, and the present article is almost entirely based upon his work. Goebel, however, who has followed—far behind—in Schimper's footsteps the study of the biological problems, has been at the trouble to collect facts observed by other investigators of Epiphytes, and has added a few examples illustrating the principles advanced by Schimper and others (3).

Compared with temperate forests, the moist tropical jungles are overwhelmingly rich in Epiphytes. There they vary in size from minute epiphyllous lichens up to the gigantic herbs or huge shrubs. Often an Epiphyte is itself loaded by countless others, on which, in turn, are crowds of smaller ones.

Most of these are confined to a few families:—Lycopodiaceæ, Ferns, Bromeliaceæ, Araceæ, Orchidaceæ, Urticaceæ, Piperaceæ, Melastomaceæ, Ericaceæ, Asclepiadaceæ, Solanaceæ, Gesneraceæ, and Rubiaceæ (as well as our temperate Epiphytes, Mosses, and Lichens). Although these families are few in number, they contain many epiphytic genera; and, with the exception of the purely American family, the Bromeliaceæ, they occur in the tropics of both

the New and Old World. These families must possess some characters which confer upon them the power of assuming an epiphytic mode of existence.

The first indispensable feature is that the seed shall be able to reach the tree on which it is to grow. The only two practicable methods of seed-dissemination are by the wind or by the agency of animals. This fact has been well illustrated by the observations of Loew (4) on the means of distribution of Epiphytes found on willow-tops in Germany. A walk along the banks of an English river, shaded by pollard-willows, reveals the fact that there is a rich epiphytic flora on these trees. Among them are not only algæ, and mosses, but also numerous herbs, and large rose and blackberry bushes. Willis and Burkill (5) found that, near Cambridge, 44·6 per cent. of these Epiphytes had fleshy fruits; 16·4 per cent. had burrs; 25·1 per cent. had winged or feathery fruits; 10·6 per cent. had very light seeds; while in only 2·9 per cent. was the means of distribution feeble or obscure.

So, in the tropics, the seeds of Epiphytes may be all ranged under three main classes:—

(i.) Those enveloped in a fleshy covering (many bromeliads);

(ii.) Seeds (or spores) very light and easily carried by the wind (*Dendrobium attenuatum*, the seed of which weighs ·00000565 grammes);

(iii.) Seeds light and with a mechanism for floating in the air. ("Wings" in *Rhododendron pendulum*, in which the seed weighs ·000028 grammes: tufts of hairs in Asclepiadaceæ: air-containing spaces in the envelope, *Æschynanthus pulchra*.)

In all cases of these regular tropical Epiphytes the seeds are small, so that they can easily become lodged in minute crevices on the surface of the host. Those characters are not adaptive. The seeds must have possessed them to a large extent when the plants were terrestrial; otherwise the latter could have never become Epiphytes. The structure of their fruits and seeds explains why certain families should not have Epiphytes among them—thus the heavy-seeded Leguminosæ. On the other hand, in certain families only those types which possessed appropriate seeds have become Epiphytes. For example, the Loganiaceæ frequently possess fleshy fruits, but the seeds are large excepting in *Fagræa*, which accordingly has epiphytic species.

Even when the seed has reached the surface it must rapidly make arrangements for the firm attachment of the embryo. Only a few observations exist on the germination of Epiphytes (*Clusia*, *Myrmecodia*, *Æschynanthus*, *Tæniophyllum*). In all these the primary root soon ceases to grow, and there is a precocious development of an extensive system of adventitious roots. In *Æschynanthus pulchra* (3) the radicle remains short, the inferior end of the embryo becomes flattened, and

its periphery swollen. In this manner a species of adhesive disk is formed and applied closely to the uneven surface of the host. The attachment is rendered all the firmer by the formation of numerous root-hairs radiating from the peripheral swelling.

Thus the whole root-system of an Epiphyte—except at a very early stage of germination—is adventitious. The same is the case with shrubs growing in our own climate on rocks or walls. In both cases this is obviously the direct effect of the mode of life.

The flowers of Epiphytes display no adaptive characters.

Concerning the modes of reproduction, vegetative multiplication is frequent. The case of *Tillandsia usnevides* is interesting. Its pendent shoots are either whisked away by the wind or carried away by birds for the purpose of constructing nests. The transferred fragments send out new shoots, which twine round the branches of the new host. This *Tillandsia* only rarely produces flowers.

It is in the structural characters of the vegetative organs that Epiphytes display the greatest amount of adaptation.

Epiphytes grow in situations where the supply of nutritive solutions is meagre and fluctuating, and where, usually, only diffused light reaches them. Moreover, they live in positions in which firm support is essential. For fixation and the absorption of nutritive solutions, a strong development of surface of the root-system is indispensable. Owing to the poverty of their water-supply, measures must be taken to avoid excessive transpiration. A desert plant accomplishes this by diminishing its transpiring surface; but an Epiphyte cannot afford to act similarly, because it requires a large assimilatory surface in order to make up for the weakness of its illumination. The Cactaceæ illustrate this point. The desert forms often have swollen, rounded shoots which are sparsely branched; but the epiphytic forms possess flat, leaf-like shoots (*Phyllocactus*, *Epiphyllum*), or have numerous thin branches (*Rhipsalis*, *Cassytha*). It only remains, then, for the Epiphytes to have leaves constructed so as to retain their supply of water. Hence the leaves are often leathery or fleshy, and frequently have a strong development of cuticle.

The mode in which Epiphytes absorb nutritive solutions serves as a basis for their classification. Appended is a brief table to show the grouping:—

CLASS I.—*Epiphytes which absorb the nutritive solutions by means of their roots.*

Group (i.) Those which content themselves with utilising the water and humus occurring on the surface of the host-plant.

Group (ii.) Those which have attaching roots and also absorptive roots which descend to the ground.

Group (iii.) Those which have arrangements for collecting water and humus.

CLASS II.—*Epiphytes which absorb the nutritive solutions by means of their leaves.*

Class I.—Group i.

The first group of Epiphytes is made up of forms which merely absorb the nutritive solutions occurring on the surface of the host-plant.

The simplest of these do not differ in any way from terrestrial plants. They live in the gloomy depths of the forest on the mossy or furrowed bark of the lower parts of trees (Hymenophyllaceæ, *Lycopodium*, and an orchid *Stenoptera*).

However, most adopt measures to guard against injury from excessive loss of water. A few forms evade injury in this respect simply by their ability to endure being completely dried up without being harmed. This is well known in the case of lichens and mosses; but certain tropical polypodies are endowed with similar vitality. Rainless weeks of the blazing West Indian sun are insufficient to scorch out of existence *Polypodium incanum*, parched though it be.

In the majority of genera there are distinct structural modifications in the form of water-reservoirs. Parts of them become fleshy and store up water. Fleshy leaves occur in ferns, orchids, and Gesneraceæ; bulbs in Amaryllidaceæ; tubers in ferns, and epiphytic Utricularias; fleshy roots in Vacciniaceæ, and the curious melastomaceous *Pachycentria*.

This water may be stored up in intercellular spaces, in ordinary parenchymatous cells, or in specialised cells ("aqueous tissue," or "storage tracheides").

The leaves of certain Gesneraceæ have, between the upper superficial layer and the green assimilatory tissue, aqueous tissue in the form of colourless cells. This tissue increases in size late in the life of the leaf, long after all other morphological changes have been accomplished. Isolating old leaves for four weeks, they diminish in thickness only to a very slight degree; but if whole branches be isolated for the same period, the old leaves become much thinner (and gradually die), because the aqueous tissue has parted with water, and has shrunk; but the young leaves are scarcely any thinner than at the commencement. These observations show that the aqueous tissue is a reservoir on which the younger leaves can draw, and that it takes on its peculiar function late in the life of the leaf.

It is, however, among aroids and orchids that the most interesting arrangements occur.

In the Araceæ, aqueous tissue is not known. *Philodendron cannifolium* may be chosen as a type of aroid belonging to this group of Epiphytes. It is a large herb with its leaves forming a rosette more than three feet in height. The stem is short and gives off numerous roots. Each leaf has a tongue-like lamina and a spindle-like petiole. The leaf possesses spongy tissue with large and conspicuous intercellular spaces. In the dry season the spaces are occupied by air, but when

the wet season comes on, the intercellular system being lined with mucilage, absorbs water which gradually replaces the air. The swollen petiole is a water-reservoir calculated to meet the demands of the lamina. This is proved by the following experiment: If a whole leaf be isolated and left to dry for fifteen days it remains unchanged in appearance; but if the lamina alone be treated thus, it fades and shrinks in a few days.

Among the Orchidaceæ, the arrangements for the storage of water are varied and characteristic. Some possess leaves with well developed broad tracheides, the function of which is to store water. In others, the water is retained in pseudo-bulbs. Experiments similar to those on *Philodendron* prove that the latter are water-reservoirs. For this reason, orchids with pseudo-bulbs usually have thin leaves; whereas, orchids with fleshy leaves are devoid of pseudo-bulbs. Only a few orchids have thin leaves and no pseudo-bulbs, but, to compensate, they have fleshy roots (*Isochilus*). Attention has already been directed to the orchid *Stenoptera* which has no water reservoir, as it grows in damp, gloomy spots.

The most curious structural peculiarity which is common to all epiphytic orchids (almost without exception) is the velamen possessed by the roots. Typically this envelope is made up of a number of layers of tracheides with perforated walls. These absorb water deposited as dew or flowing down the surface of the host; but it is quite a mistake to suppose that they have any appreciable power of condensing moisture from the atmosphere. The velamen is not always an absorptive layer. In *Bromheadia alticola* (6) it is a sheath to prevent the evaporation of water which is absorbed by root-hairs which attach the plant to the substratum.

The question arises, "Is the velamen really adaptive?" I am of opinion that the answer must be given in the affirmative, in spite of the cautious scepticism of Schimper on the subject. With the single exception of one species of *Stenoptera*, all epiphytic orchids have a velamen. All other known species of *Stenoptera* are terrestrial, and this species only grows in damp, moss-laden, furrowed bark in the lower regions of forests; moreover, its structure is purely terrestrial. We must conclude that this *Stenoptera* has only recently adopted its epiphytic mode of existence (6). On the other hand, with the exception of two species, all terrestrial orchids known are devoid of a velamen. *Epidendrum cinnabarinum* is one of these exceptions, and has a velamen. Now it is almost always a terrestrial orchid, but Fritz Müller[1] has found it as an Epiphyte. It is a renegade Epiphyte which has become terrestrial, as is confirmed by the occurrence on it of useless aërial roots, and by the fact that its relatives are Epiphytes. The other exception is the purely terrestrial *Bromheadia palustris* (6). It undoubtedly has been derived from an epiphytic form. It possesses a curious impermeable velamen like that of the epiphytic *B. alticola*; but this velamen is exceed-

[1] Communicated by letter to Professor Schimper.

ingly transitory and peels off almost simultaneously with the root-cap cells. The last reason for believing that the velamen is adaptive is afforded by its re-appearance in Epiphytes belonging to the widely-separated family, the Araceae. Thus Epiphytes acquired their velamen after they had deserted their terrestrial mode of life.

When young, the aërial roots of orchids usually contain chlorophyll; but their assimilatory function is insignificant. However, in *Æranthus* and in *Taeniophyllum* the leaves are reduced to scales, while the roots are large and green. The plant consists almost solely of root-system. In the roots of *Æranthus*, Schimper discovered that certain regions of the velamen are impermeable to water, but are easily penetrated by air. These regions obviously function as stomata do in leaves. In *A. fasciola* the leaf-like appearance of the roots is heightened by their dorsi-ventral structure.

Class I.—Group ii.

Members of the second group of Epiphytes possess roots of two sorts—they are hence heterorhizal, and exhibit an advance on the first class. When the seed germinates on the host-plant, some roots are produced which clasp the host like tendrils. These are purely organs of attachment. The plant also produces long nutritive roots which descend rapidly to the ground.

Such roots are possessed by *Clusia* and *Ficus*, among *Dicotyledons*: and by species of *Philodendron*, *Anthurium*, and *Carludovica*, among *Monocotyledons*.

The attaching roots are negatively heliotropic, but have no marked geotropic properties. They have a slow, definite growth, and coil closely round their support, giving off numerous root-hairs. They have no absorptive function. In them the xylem consists mainly of thick-walled lignified fibres with relatively few and narrow conducting constituents.

The nutritive roots, in some cases, possess negatively heliotropic characters, but they are always positively geotropic to an eminent degree. Their growth is rapid and indefinite, some roots attaining a length of more than a hundred feet. Till reaching the soil they remain thin and unbranched, but on dipping into the soil they give off numerous subterranean lateral roots. The nutritive materials from the soil have to travel over long distances by way of these roots. The conducting constituents of the xylem are accordingly numerous and prominent, whereas the fibres are feebly developed. The necessary amount of rigidity is ensured by the formation of peripheral sheaths of sclerenchyma or collenchyma.

Clusia and *Ficus* frequently "strangle" their hosts by investing their trunks with a fenestrated cylinder formed of the fused roots which embrace the trees on which these Epiphytes originally lodged.

Class I.—Group iii.

The members of the third group possess arrangements for the

retention of decaying humus-giving bodies, and the roots frequently branch copiously in the air, some of them deserting the surface of the host.

In many epiphytic orchids there are attaching roots which are negatively heliotropic, and in addition clusters of erect negatively geotropic roots which are wholly absorptive in function. In orchid houses, potted specimens of these orchids frequently possess roots growing vertically upwards out of the soil (species of *Cymbidium*, *Eulophia*); but there is no reason to believe that these roots act thus in order to supply the subterranean parts with oxygen. They simply point upwards because, when the plants are growing in their natural position (as Epiphytes), the nutritive materials come from above, and are absorbed by these peculiar roots.

An aroid, *Anthurium Hügelii*, is a good type of an Epiphyte belonging to this group. Although a large plant, it is often to be found fastened to the smooth aërial roots of *Clusia*, or to the band-like stems of *Bauhinia*. It is fixed to its support by means of very long roots, which stretch along the surface of the host and give off root-hairs only on the side towards the latter. An extensive rounded complex of roots surrounds and overtops the dwarfed stem, and gives off numerous lateral roots among the sub-sessile leaves. The last-named form a large rosette enclosing a mass of vegetable fragments, which decompose into humus. The complex is composed mainly of much branched and hairy nutritive roots which are closely interlaced at their bases, but which possess apices freely protruding into the air or dipping into the humus.

In this plant, as in the rest of this group of Epiphytes, the structural differences between the attaching and nutritive roots are not so wide as in the second group. This is due to the fact that the attaching roots absorb water to a certain extent, and that the nutritive roots do not conduct the absorbed substances over long distances. Still, the nutritive roots of *Anthurium Hügelii* possess larger and more numerous vessels and fewer sclerenchyma-fibres than do the attaching-roots.

Some ferns have precisely similar arrangements, *e.g.*, *Polypodium phyllitidis*.

In other ferns the humus is collected by single leaves which form pockets against the surface of the host's stem, or against their own stems. In *Polypodium quercifolium* (3) the differentiation has gone so far that there are two sorts of leaves: in the first place, ordinary stalked pinnate leaves; secondly, sessile negatively geotropic leaves, which form pockets against the opposed surface. The latter assimilate only for a brief period, but persist as large, dead, yellow oak-like leaves. Thus when dead they do not drop off (as do the normal foliage leaves), but, being strongly ribbed, persist as receptacles for humus.

Another heterophyllous Epiphyte is the curious twining, pitchered

Dischidia rafflesiana. Some of its leaves are hollowed out into pitchers. It has roots of two sorts—attaching and nutritive. The latter are given off into the cavities of the pitchers, within which they ramify. Treub (7) was of opinion that these pitchers functioned solely, or mainly, as receptacles for rain-water and economisers of the water transpired within the pitchers. He showed that the epidermis lining the pitcher-cavity could not absorb water. But I have shown that very considerable amounts of humus-providing materials are collected in these pitchers (8), and that the roots within the pitchers absorb this food placed at their disposal. These pitchers have the same function as the rosettes of *Anthurium* or the "pocket-leaves" of ferns —they collect humus. However, they are able to collect more water than is possible to their simpler analogues. One curious fact about these pitchers is the constant presence of ants living within them. Probably a large portion of the food found in these pitchers is conveyed thither by the ants. The plant provides shelter for the ants, and they in return bring these materials (for the purpose of building nests).

Externally unlike *Dischidia rafflesiana*, but very similar in fundamental design, are two Rubiaceous Epiphytes—*Myrmecodia* and *Hydnophytum*. In each of these genera the base of the stem takes the form of a great swollen tuber, which is hollowed out by a series of galleries or canals continuous with one another, and communicating with the exterior by, mostly small, apertures. These galleries are always found to be occupied by innumerable ants belonging to a certain definite genus and species. In a typical case, lenticels occur in the walls of the galleries from which there protrude, more or less, distinct roots. In principle, then, this great tuber corresponds to a pitcher of *Dischidia*; the stomata of the epidermal lining of the pitcher correspond to the lenticels opening into the galleries; and the roots protrude into the galleries and the pitcher-cavity respectively. Rain-water can only pour into some of the pitchers of *Dischidia*, because their mouths sometimes point downwards; but rain-water can enter freely into the galleries in only one known species. In most cases, the external openings of the galleries are so small that water could only enter in the form of a thin capillary film. Formerly it was supposed that the ants constructed the galleries, and that these animals were essential to the existence of these plants; but Treub (9) showed that the galleries developed in the absence of ants, and that the plants could exist without the proper ants. The hypothesis that the galleries are respiratory passages is quite inadequate. The whole arrangement has been looked upon as a mechanism for the economy of water. This hypothesis is backed up by no experiments, and, at present, is only bolstered up by a few facts, and more or less distant analogies.

It is still possible that the ants have been the prime factors in the evolution of these excavated tubers. The development of the

galleries is not out of harmony with this view. The observation that under cultivation these plants live without their ants, tells us naught of what would happen to them in their wild state under similar circumstances; and it is futile to object that the plants cannot be myrmecophilous (ant-loving) because they do not attract ants by means of honey or food. Ants are attracted to these plants. This is proved, first, by the constant presence of a certain definite species of ant in specimens growing wild; and, secondly, by the extreme difficulty in preventing ants crowding on cultivated seedlings of these plants, even when adjacent seedlings of other plants are neglected. It is possible that ants convey into the galleries materials which can be subsequently utilised by the roots therein. But at present *Myrmecodia* and *Hydnophytum* are living mysteries.

Class II.

The second class, represented by the Bromeliaceæ, stands apart from the types previously described in that food and water are absorbed by the leaves—and not to any appreciable extent by the roots.

Often the leaves together form a very close rosette—a funnel—which contains water with humus-giving bodies. By isolating some of these funnel-forming bromeliads, Schimper proved that the leaves absorbed nutritive solutions. Living specimens were deprived of their roots and the wounds were closed with Canada balsam. Water was poured into the funnels of some of these, but the rest were kept without water. The former remained fresh as long as the experiment lasted—ten to twelve weeks; but the latter died in the course of a few days or weeks. Water supplied only to the roots of isolated specimens neither restored faded plants nor appreciably retarded the death of freshly isolated individuals. This experiment shows that the roots absorb only a negligible amount of water—they are purely organs of attachment. Hence epiphytic bromeliads which have other means of fixation are devoid of roots.

Tillandsia usneoides is one of the commonest rootless Epiphytes belonging to the Bromeliaceæ. This plant forms silvery-grey, pendent masses, which resemble horses' tails or manes. These tufts attain lengths of more than ten feet. Each thread consists of a filamentous distichous shoot, which, at its base, twines round a branch of its host. Hanging down as it does, the plant possesses no external, funnel-like reservoir for water.

The water is absorbed by means of certain peculiar scaly hairs. In funnel-forming bromeliads these are confined to the basal parts of the leaves, thus they only occur in the region of the water-reservoirs; but in forms, like *Tillandsia usneoides*, having no external receptacle for water, the scaly hairs are distributed over the whole surface.

In *Tillandsia*, which may serve as a type, each scaly hair consists of: (i.) a stalk-like *base* sunk into the tissue; (ii.) a peltate upper part

—the *shield*—lying flat over the surface of the leaf. This shield has a central group of cells, and a thin extended margin composed of cells or cell-walls. Underneath the *base* is a group of three cells on top of one another; they are protoplasmic and have thin uncuticularised walls (except sometimes the lowest wall is thick but pitted). These three cells are "passage-cells."

If a drop of water be placed on a leaf of *Tillandsia usneoides*, the silvery-grey appearance is locally replaced by a green colour. Examination with a microscope reveals the fact that at first the central cells of the *shield* contained air, but on supplying water these cells become filled with it. Placing a drop of caustic potash or strong sodium chloride solution on the leaf, it can be seen that the colour changes or plasmolytic phenomena commence first in the epidermal cells nearest the scaly hairs, and gradually advance to more distant cells. Finally, the cells composing the sheets have their lower walls thin and uncuticularised, as also are the walls of the stalk and passage-cells; whereas the rest of the epidermal cells have thick cuticularised walls. Again, terrestrial bromeliads which have absorptive roots possess scaly hairs which are incapable of being wetted. These facts prove that the peculiar scaly hairs of the epiphytic bromeliads absorb nutritive solutions. The upper wall of the scaly hair is thick and heavily cuticularised. It functions as a mechanism to prevent evaporation of water. Accordingly when those hairs are sunken it is relatively thin, but in protruding hairs it is thick. When the central cells of the shield contain air their lateral walls are crumpled so that the shield lies close above the surface of the leaf (thus preventing loss of water by evaporation); but when these cells absorb water, their walls straighten and thus raise the shield above the general surface.

It is impossible to mention all Schimper's interesting observations on this part of the subject. However, he points out that some terrestrial bromeliads possess absorptive scale-hairs, and he makes out a good case for the view that the possession of these scaly hairs in epiphytic Bromeliaceæ is not adaptive, but that these plants become epiphytic because they already possessed these curious hairs.

General Conclusions.

It has been pointed out that in the first three groups forming Class I. the nutritive solution is absorbed by the roots. In the first group no provisions are made for the collection of water or humus otherwise than from the surface of the host-plant. This group commences with the simplest forms which are entirely terrestrial in structure, and only grow on the lower parts of trees in damp and ill-lighted spots; but the rest of the group are characterised by a great development of the surface of the root- and leaf-systems. The leaves have a thick cuticle, etc., to avoid excessive transpiration: and internal water-reservoirs are usually present. But owing to the poverty of the supply of water and humus, and to the simple measures adopted in

utilising these, the plants in this group are, for the most part, merely small herbs.

In the next two groups the xerophytic structure is, on the whole, less pronounced; for these forms have advanced and have adopted means to ensure a richer supply of food and water. In the second group the roots have become differentiated into two sets—attaching and nutritive. The latter descend to the ground. These forms can be directly derived from the first group, and intermediate types occur in which the nutritive roots reach the ground rather by chance than in virtue of any strong geotropic properties (*e.g.*, some Cactaceæ).

The third group has for the most part roots differentiated into attaching roots and absorptive roots which desert the substratum and often are negatively geotropic. The roots or leaves, or both, make provisions to collect humus. In the highest types not only are there two sets of roots, but there is a differentiation in the leaves, some of which are set apart to collect humus (species of *Platycerium*, *Polypodium*, and *Dischidia rafflesiana*). This group, too, is derived directly from forms like the first group.

The second class—the Bromeliaceæ—have been derived directly from terrestrial bromeliads. They have become epiphytic in virtue of the power which their leaves already possessed of absorbing nutritive solutions. They have been formed utterly independently of, and have pursued a course quite different to, that of the first class. Yet it is striking to note how the effect of the environment has been stamped on forms belonging to the two classes; and to see how the physiological anatomy of two forms may be identical and yet attained in a totally different matter. For instance, comparing *Tillandsia usneoides* with *Æranthus*, both are formed of pendent, green, assimilatory organs. Yet the one is wholly made up a shoot-system, and the other, practically, entirely a root-system. In both there is a general external absorptive mechanism—numerous scales and velamen respectively. The nutritive solution reaches the assimilatory tissue after first passing through a layer cuticularised except at certain points—the "exodermis," with thin-walled passage cells, and the epidermis with the passage cells under each scaly hair. Here and there free communication exists between the atmosphere and the assimilatory tissue—by stomata in one, and by air-containing patches in the other. The assimilatory tissue lies within the cuticularised layer. Rigidity is ensured in both by sclerenchyma-fibres. In both there is a feebly-developed vascular system, corresponding to the fact that each part of the whole surface is capable of assimilating and of absorbing nutritive solutions, and that hence conduction over long distances is not necessary.

Distribution of Epiphytes within their own Region.

Moisture is the first great factor which controls the distribution of Epiphytes. This is true, not only of the distribution of Epiphytes

in their own region, but also over the world as a whole. It is not temperature which determines the presence or absence of Epiphytes. They are absent from deserts which have a tropical temperature; whereas shrubby representatives of this class are to be found on the Himalaya, in regions where the average temperature is below that of England.

This demand for moisture is well illustrated by the distribution of Epiphytes in England. Out in the open they are confined to a few lichens, minute algæ, few mosses, and a couple of sorts of liverworts. But in woods, where the air is damper, the number of these epiphytic forms is much greater, and occasionally ferns are found epiphytic. Where dampness of the air is combined with good illumination, there is a still richer epiphytic flora; for instance, on pollard-willows lining a river-bank there are many Epiphytes, some of which attain the size of bushes (Rose, etc.).

So, in the tropics, the moisture-laden jungles and primæval forests abound in Epiphytes; on the other hand, the open savannahs have but few.

The second controlling factor is *light*. The demand for light drives Epiphytes to the tops of the trees in a tropical forest. In wandering through one of these forests it may seem as if there are but few Epiphytes, till one espies their great aërial roots descending to the soil and their fallen flowers and fruits dappling the ground.

To a certain extent, light and moisture are wants which the Epiphyte cannot obtain at the same time to the fullest extent. In general, one may say that shade involves a moister atmosphere and illumination a drier one; in addition, the stronger the light, the more rapidly does a leaf transpire. Hence, in a tropical (American) forest, one finds the Epiphytes ranged at different heights up the trees, and the same forms constantly occur in the same positions. Low down in the shade, on the trunks or thick lower branches, there are but few. These are moisture-loving and shade-bearing species, especially Hymenophyllaceæ, Lycopodiaceæ, delicate *Peperomias* and orchids (*Zygopetalum*), green bromeliads. On the tree-tops are forms which can endure strong light, and are constructed so as to withstand the danger arising from excessive transpiration (grey *Tillandsias*, thick-leaved orchids without pseudo-bulbs, leathery polypodies). Between these two extremes, on the branches below the tree-tops, the richest and most varied epiphytic flora prevails. It is at this level that the giants among Epiphytes reign, and countless orchids with pseudo-bulbs flourish.

Going out into the tropical American savannahs we find the Epiphytes far fewer. They are largely identical with those growing at the extreme tops of the forest-trees. Only a few forms from the middle stratum of Epiphytes occur, but none from the lowest stratum.

Corresponding to the above-mentioned facts, we find that densely-foliaged trees have few or no Epiphytes on them (Mango),

unless indeed the tree have deciduous leaves (South Brazilian fig trees), in which case numerous Epiphytes occur.

The *nature of the surface* of a plant also determines the number and sort of Epiphytes which lodge on it. Only a few forms can exist on very smooth surfaces. These are chiefly Bromeliaceæ, which may be found on polished stems of palms, in glassy shoots of bamboos, on leaves, and on smooth aërial roots. They are the pioneers among Epiphytes, as they germinate on smooth spots unsuitable to other forms. Among their roots these more exacting plants settle, so that a colony of Epiphytes springs up round the originally solitary bromeliad.

On the other hand, there are forms which cannot live except on very uneven surfaces, on rough or mossy bark, in the persistent leaf-sheaths of palms (especially ferns).

Most Epiphytes avoid trees with a peeling or scaling bark.

In addition, the distribution of Epiphytes on plants depends on causes not yet understood. For instance, an epiphytic orchid in North Florida especially affects *Magnolias*. *Crescentia cujete* is a tropical American tree which is the greatest favourite with Epiphytes. Schimper suggests that this is due to the facility with which root-hairs penetrate its soft superficial cork.

The Evolution of Epiphytes.

We are now in a position to trace out the mode in which terrestrial plants became Epiphytes in tropical America, and similarly in other tropical regions.

In the primæval forests one sees terrestrial forms allied to the epiphytic species growing at different heights up the trees. This is not so in the open country, say in the savannahs, where the Epiphytes are allied to those occurring in the tops of the trees in the forests. This fact, and the general principle that moisture of the air largely determines the presence, or absence, of Epiphytes, leads us to the result that Epiphytes were evolved in the regions of moisture —the forests.

There are now species which grow in the forests as terrestrial plants or as Epiphytes, but in the latter case they invariably grow in moist gloomy spots on the lower part of trees; and, in general, shade-loving forms occupying positions low down on the trees are the simplest and least modified Epiphytes. They are the most recent recruits in many cases.

Thus to us comes the idea that when Epiphytes started their aërial mode of existence, they commenced in these shady moist positions not far above the ground. I may suggest that this view of Schimper's receives support when one particular group of Epiphytes is considered—that is, the group in which some of the roots descend to the ground, often having to be more than a hundred feet long to attain this. The evolution of such roots is absolutely inconceivable,

unless we suppose that the epiphytic ancestors of the plants possessing them were once much nearer the ground than their present representatives are.

The plant, then, having become an Epiphyte occupying the lower regions of the forest, its next demand would be to get into more strongly-lighted places so as to assimilate at a greater pace. So the next step was for the Epiphytes to climb higher up the trees. With this arose the necessity for provision against excessive transpiration and for more elaborate organs for absorbing water. Gradually, then, the Epiphytes crept up the trees, becoming more adapted to their habitat as they struggled with one another (and with their hosts) in the fierce battle for light. In this manner they reached the higher branches of the trees—but below the tree-tops. This is the paradise of the Epiphytes; the light is not too intense, but filters through a veil of leaves.

To escape their many competitors, a few bolder spirits advanced almost into the full blaze of the sun on the tree-tops, taking measures, as they ascended, to avoid being parched. From these points of vantage, some of them, and a few from the middle stratum, winged their way to the savannahs, others climbed mountains and became tropical alpine forms living on the ground (1). Still others journeyed to the sea-coast, and descending to the ground became littoral forms with their roots dipping into the salt-laden soil (1). A few which have entirely, or almost entirely, deserted their epiphytic mode of life bear structural evidence of their former epiphytic mode of existence (6).

REFERENCES.

1. **Schimper, A. F. W.**—Ueber Schützmittel des Laubes gegen Transpiration besonders in der Flora Javas. *Sitzungsber. d. Königl. preuss. Akad. d. Wissensch.* Berlin, 1890, p. 1045.
2. ———————.—Die epiphytische Vegetation des Amerikas. *Bot. Mittheilungen aus den Tropen*, ii.
3. **Goebel, K.**—Epiphyten. *Pflanzenbiologische Schilderungen*, i.
4. **Loew, E.**—Anfänge epiphytischer Lebensweise bei Gefässpflanzen Norddeutschlands. *Verhandl. d. Bot. Ver. Prov. Brandenburg*, vol. xxxiii.
5. **Willis, J., and Burkill.**—Paper in *Proc. Cambridge Phil. Soc.*, 1893.
6. **Groom, Percy.**—On the Velamen of Orchids. *Annals of Botany*, vol. vii.
7. **Treub, M.**—Sur les urnes du *Dischidia rafflesiana*. *Ann. Jard. Bot. Buitenzorg*, vol. iii.
8. **Groom, Percy.**—On *Dischidia rafflesiana*. *Proc. Roy. Soc.*, vol. liii.
9. **Treub, M.**—Sur le *Myrmecodia echinata*. *Ann. Jard. Bot. Buitenzorg*, vol. ii.

PERCY GROOM.

II.

On the Relation of the Fauna and Flora of Australia to those of New Zealand.

THAT the flora of New Zealand should present so many features akin to that of Australia, and yet entirely want the distinctive botanical characters of its nearest continent, is a problem to which Hooker first drew attention. No solution was attempted by that writer, who limited his discussion of the question to a clear statement of the facts in a passage[1] so frequently quoted that it need not be here repeated.

The explanation offered by Wallace in "Island Life," and generally accepted, is: (1) commencing the biological history of Australia with the Cretaceous era, that Eastern and Western Australia were then totally severed; (2) that Eastern Australia was at that time quite devoid of a typical Australian terrestrial fauna and flora, which was then confined to Western Australia; (3) that a large area of what is now the floor of the Tasman Sea was upheaved, and nearly, or quite, connected New Zealand with Australia, whereby the flora and fauna, then existing in Eastern Australia, were enabled to colonise New Zealand; (4) that this hypothetical bridge then sank, isolating the New Zealand colonists, and afterwards dry land appeared between Eastern and Western Australia, upon which the characteristic Australian forms first crossed from west to east.

Apart from the difficulty they are supposed to satisfy, little or no evidence is advanced for the support of these propositions. That a Cretaceous sea separated Eastern from Western Australia may be granted, but that at any time Western Australia possessed a monopoly of characteristic Australian plants or animals is improbable. Recent discoveries show that the dry land representing Western Australia in Cretaceous times was much less than Wallace supposed, and than appears in the sketch map on p. 497 of the second edition of "Island Life." In the region explored by the Elder Expedition, "an area of Mesozoic formation extends as far as long. 123°."[2] The shallow inland Cretaceous sea was studded with islands, large and small, which served the fauna and flora as stepping-stones in their migrations from west to east and from east to west. Some of these are now

[1] J. D. Hooker, "Introductory Essay to the Flora of Tasmania," pp. lxxviii.-ix.

[2] V. Streich, "Scientific Results of the Elder Exploring Expedition, Geology," p. 88.

represented in Central Australia by the Macdonnel, Musgrave, and Everard Ranges;[3] in Queensland by an extensive area of Palæozoic schists, extending almost from the Gulf of Carpentaria to beyond Cloncurry, reappearing in the south as the Grey and Stokes Ranges,[4] and yet again in New South Wales as the Barrier Range. If allowance be made for denudation, more islands probably then existed than geological maps now indicate. Tertiary fossils from Victoria, N.S.W., and Queensland show as marked an Australian facies as recent plants and animals. Such are the various species of *Banksia* from the Lower Miocene.[5] The very characteristically Australian remains preserved in the Darling Downs' deposits cannot, says De Vis, be considered as of later date than Early Pliocene.[6] Finally, many genera and species among recent plants and animals essentially Australian are confined to Eastern Australia. Wallace correctly remarks that West Australia is richer than the East in peculiarly Australian plants, but when, as described later, the archaic Queensland flora was submerged and almost extinguished by the Papuan invaders, great numbers of such peculiarly Australian plants must have perished in Eastern Australia.

More in need of confirmation than the preceding propositions stands the theory that a large tract of the Tasman Sea connecting Australia with New Zealand was upheaved, and when it had served its purpose conveniently, subsided at the close of the Cretaceous. Except about the twentieth parallel, where a bank no deeper than 1,300 fathoms connects the Great Barrier Reef with New Caledonia, the shores of Eastern Australia everywhere front deep water of over 2,000 fathoms, to the north the abyss of the Coral Sea, to the south that of the Tasman Sea. The geological history of this coast, as opposed to that of New Zealand, indicates great stability; such a vast elevation and subsequent depression as Wallace demands could scarcely have occurred without leaving signs decipherable by geologists. If the upheaval was local instead of general, it must, to satisfy the theory, have taken place between Bowen and Rockhampton, where the Caledonian Barrier Bank abuts on the Queensland coast. No consequent distortion of the strata appears to have been there observed by local geologists.

Upon detailed examination, it appears that although the fauna of New Zealand sometimes approximates to that of Queensland, yet it could not have been derived therefrom; that, in short, the relation is not that of mother and daughter, but that of sisters. An analysis of the Australian land shells shows the range of the operculated forms

[3] V. Streich, *Op. cit.*, p. 80.

[4] *Vide* sheets 3, 4, and 5 of the Geological Map issued with "The Geology and Palæontology of Queensland and New Guinea." By R. L. Jack and R. Etheridge, Jun.

[5] Ettingshausen, "Contributions to a Tertiary Flora of Australia," pp. 138-143.

[6] C. W. De Vis, *Proc. Linn. Soc. N.S.W.* (2), vol. vi., p. 456.

to be restricted to the coast of Queensland, and that, proceeding from south to north, the group becomes gradually richer in species and in genera. In the New Zealand fauna the operculates are represented by a tenth of the snail fauna as compared to none in Australia, except Queensland, to one-sixth in Queensland, and one-third in New Guinea. So far our investigation conforms to Wallace's theory, and as that demands an origin in Australia for the New Zealand fauna, so we expect the operculate land mollusca of New Zealand to be descendants of those of Queensland. Here, however, facts rebel against the theory, the New Zealand species being ranked under *Lagocheilus*, *Realia*, and *Hydrocena*, while the Queensland ones are contained in *Georissa*, *Truncatella*, *Pupina*, *Callia*, *Pupinella*, *Hedleya*, *Ditropis*, *Diplommatina*, *Leptopoma*, and *Helicina* ; than which two faunas could hardly be more distinct.

Most European writers who have touched on the zoo-geography of Australia have described the fauna and flora as falling into a temperate and a tropical division, which again subdivide into eastern and western sections. A little real experience proves these divisions to be quite artificial. The dry interior, for example, is everywhere inhabited by the same plants and animals, regardless of latitude or longitude; examples are, the great red kangaroo among mammals, the plain turkey, the maller hen and the rosy cockatoo among birds, the frog *Notaden bennetti*, the lizard *Lygosoma monotropis*, and the snakes *Pseudonaja nuchalis* and *Hoplocephalus nigriceps*, among plants the predominance of salt-bush, spinifex, gidya (acacia), and *Frenela*. On the eastern seaboard, the difference between north and south is that between a conquering and invading fauna and flora and the indigenous population where not exterminated or obscured by them. The types encountered by a traveller in tropical Queensland, or rather in that narrow belt of tropical Queensland hemmed in between the Cordillera and the Pacific, all wear a foreign aspect. Among butterflies the *Ornithoptera*, among reptiles the crocodile, among birds the cassowary and rifle bird, among mammals the tree kangaroo and the cuscus, and among plants the profusion of epiphytic orchids and of palms, all point to a northern origin. In the heart of a great Queensland "Scrub" a naturalist could scarcely answer from his surroundings whether he were in New Guinea or Australia.

Late in the Tertiary Epoch, as I read the record, Torres Straits, now only a few fathoms deep, was upheaved, and across this bridge there poured into Australia a stream of Papuan life. Between the coastal range and the sea as far as the tropics the irruption flowed in undiminished strength; on reaching the border of N.S.W. the cooler climate diminished its vigour, and at the Clarence River, N.S.W., with few exceptions, it found its southern limit. Within this area grow side by side, like oil and water—touching yet not commingling, two distinct vegetations, the dense Papuan jungle called "Scrub" by the Queenslanders, which has usurped every rich volcanic upland and

every fat alluvial plain, and the lightly timbered "Forest" of acacias and eucalypts confined to the inferior soils. As sharp a line is drawn between "Scrub" and "Forest" as a European may see between an Alpine meadow and a thick pine wood.

In considering the contour of the floor of the Western Pacific in relation to the distribution of species, we are greatly hampered by want of information. Too few and distant are the deep-sea soundings to determine the trend of the numerous banks and troughs of this region. Something can, however, be deduced from the "Challenger" discoveries. When that vessel ran a line of soundings across the Coral Sea, she found that the temperature of the soundings diminished down to 1,300 fathoms, below which depth it was stationary, proving that no cold stream from the depths of the Central Pacific or Antarctic Oceans could penetrate and chill this basin;[7] from which it is to be inferred that no gap deeper than 1,300 fathoms crosses the rampart extending from the Solomons to New Zealand. This region, in contrast to Australia, is one of great volcanic activity, and there are evidences of great fluctuation of levels in the past. If we consider that this track was ridged up by the contraction of the floor of the South Pacific, the fact would be accounted for that the various earth-waves of this plateau—for example, the Southern Alps of New Zealand—all curl, or have their steepest face towards Australia; and this argument, if granted, would render more probable the former existence of a continuous land-surface from the Solomons to New Zealand. It would explain the undisturbed condition of the Australian Tertiary and Mesozoic beds, which escaped the shocks of contraction, as compared with those of New Zealand which received them. Holmes and Hinde assume from the contained sponge remains that the siliceous beds of Oamaru, New Zealand, were formed at depths of not less that 6,000 to 9,000 feet in Eocene seas[8]; while Guppy considers that since Post-tertiary times the Solomon Archipelago has been upheaved at least 12,000 feet.[9] The vertebrate fauna of the Solomons evinces a recent descent from Papuan types, apart from which it shares with the New Hebrides and New Caledonia that remarkable poverty of mammalian and reptilian forms so distinctive a trait of New Zealand. Besides this negative evidence may be adduced the instructive distribution of *Placostylus*. This large Bulimoid snail forms one of the most striking components of the snail fauna of New Zealand, Lord Howe Island, New Caledonia, the New Hebrides, the Solomons, and the Fijis. This distribution appears to be in no way connected with trade winds or ocean currents. On the supposition that the remoter colonies of *Placostylus* were seaborne emigrants, it would be difficult to explain how, when Lord Howe was populated from New Zealand

[7] Voyage of H.M.S. "Challenger," narrative, vol. i., p. 519.

[8] *Journ. Linn. Soc.*, vol. xxiv., pp. 178 and 255.

[9] H. B. Guppy, "The Solomon Islands, their Geology, etc.," p. 126.

or New Calendonia, that the emigrants who had successfully traversed the wide and shallow portion of the Tasman Sea should be stayed by the narrower but profound waters from reaching Australia. Similarly, a narrow but a deep strait intervenes between Fiji with numerous species and Samoa with none, between the Solomons where the genus is well represented and the Louisiades where it is absent. The beaches of Queensland, as I can testify from personal observation, are strewn by a constant drift of pumice accompanied by coco-nuts and pearly nautilus shells. The coco-nuts might have floated from any tropical island in the Pacific, the nautilus shells are only derivable from the narrower limits of the Solomons, the Fijis, and the New Hebrides, while the pumice must almost certainly be the product of the active volcanoes of the New Hebridean group. It is therefore obvious that in the Western Pacific the chief route of drifting objects is that of the trade winds from N.E to S.W. To an objection that the range of *Placostylus* might be due to transmarine migration, it is a sufficient answer to observe that this genus extends beyond and across, but not parallel to, the direction of the principal agency of dispersal in this region. Both birds and plants contribute evidence of the homogeneity of the fauna and flora of these islands, and of their distinctness from those of Australia. Among the former may be quoted *Merula* and *Aplonis*, and especially the distribution, past and present, in Lord Howe, Norfolk Island, and New Zealand of *Nestor*, *Platycercus*, *Notornis*, and *Ocydromus*.[10] Of the botany of Lord Howe Island it is especially to be remarked that, whereas on Wallace's theory it should, lying nearest to Australia, be most akin to that region, yet "those typical Australian families the Leguminosæ and the Myrtaceæ are barely represented, whilst the Proteaceæ are said to be wholly wanting."[11]

Upon these grounds I conjecture that an ancient continent, separated on the west from Australia by the abysses of the Coral and of the Tasman Seas, is represented by the Solomons, the Fijis, the New Hebrides, New Caledonia, Lord Howe, and New Zealand, with its outlying islands—an area that I have elsewhere[12] proposed to call the Melanesian Plateau, and upon part of which Forbes has more recently conferred the name of Antarctica.[13]

In conclusion, I would contend that New Zealand is associated with the Solomons and the New Hebrides, firstly, as a member of their volcanic system; secondly, by community of fauna and flora; whereas to Australia it is related not at all physically, and to a foreign and intrusive element biologically; and that a theory which derives the fauna and flora of New Zealand primarily from these archipelagoes and remotely from New Guinea, necessitates fewer unproved assumptions than that which derives them from Australia.

C. Hedley.

[10] R. Etheridge, Jun., "Lord Howe Island, General Zoology," p. 13.
[11] R. Etheridge, Jun., *op. cit.*, p. 108. [12] *Proc. Linn. Soc. N.S.W.* (2), vol. vii., [13] See Natural Science, vol. iii., p. 54. [p. 335.

III.

Recent Researches on the Fauna and Flora of Madagascar.

THE remarkable faunal riches of this African island have been chiefly made known in M. Grandidier's volumes, but there is still much material at Paris lost to science for want of someone energetic enough to work it out. Particularly so is this the case with the Mammalia, and the delay in publication is not only vexatious to the zoologist, but allows others to describe as new, recent accessions, of which specimens are probably buried in Grandidier's collections.[1] The practice, too, of issuing volumes of plates unaccompanied by descriptions, may, perhaps, be useful when dealing with the larger animals, but is absolutely valueless (even to secure priority) for insects or plants in which so much depends on microscopic characters, and can only lead to endless confusion in nomenclature.

The latest information about the Madagascar fauna as a whole may be found in chapter xix. of Wallace's "Island Life" (ed. 2, 1892); but since that time, thanks to the liberal-handedness of Mr. Grose Smith and Mr. Walter Rothschild, material as remarkable for its abundance as for the peculiar value of the specimens has been received in this country; nor must it be forgotten that other workers, such as the Rev. R. Baron and M. Gautier, are largely interesting themselves in the accumulation of material which, though less in quantity, is every bit as valuable as the collection made by Mr. Last. Indeed, one may safely say that any remains, whether fossil or recent, if properly localised and carefully packed, add new light to our imperfect knowledge of this great island.

MAMMALIA.—The remains of Hippopotamus from the Post-tertiary deposits of the island have been known since the time when Murchison exhibited to the Geological Society in 1833 a tusk and molar tooth from a conglomerate, some 30 miles from Antananarivo. Further remains of what may be considered to be the same species were described by Grandidier and Milne-Edwards in 1868 as *H. lemerlei*. Portions of the skull of another individual of possibly the same

[1] We understand that a monograph on the genus Lemur, by Milne-Edwards and Filhol may shortly be expected, accompanied by 60 anatomical plates, when we hope the plates issued in 1890 will be properly described.

species have recently been received in London, and will form the subject of a paper by Dr. Forsyth Major.

In June last, Dr. Major read before the Royal Society a paper on an extinct Lemuroid from Ambolisatra, a slightly imperfect skull—with a right and left mandibular ramus—of which has been sent to this country by Mr. Rothschild's collector, Mr. Last. This skull, belonging to an animal approximately three times the size of any described Lemuroid, has been named *Megaladapis madagascariensis*. It is characterised by an enormous lateral development of the anterior inter-orbital portion of the frontals; a comparatively narrow and elongated post-orbital frontal region, separated by a slight contraction from the equally narrow parietal region; a thick and flattened sagittal, and an equally strongly developed occipital crest. The zygomatic arch is high and projects moderately outwards. The general appearance of the skull and teeth indicate an old individual. The brain-case is comparatively small in size, and is viewed by Dr. Major as a degenerate feature, and he anticipates that in young specimens the cranium would be more rounded in the cerebral region, more voluminous, and the facial portion much shortened.

Evidence has also been forthcoming of the former existence of a ruminant, but the remains are too imperfect to permit of identification. The colossal hippopotamus and rhinoceros (six times the size of an elephant) of M. Hamelin (*Standard*, 25 July) are imaginative, and the reported destructive powers of the *Cryptoprocta*, which attains a size about equal to that of a lynx, is, we venture to think, somewhat exaggerated.

AVES.—Many remains of *Æpyornis* have been received during recent months, some of which—sent to Mr. Rothschild, and exhibited by him at the Zoological Society—far exceed in size any specimens previously recorded. An egg of this bird was sold in a London sale-room a few months ago in a perfect condition, realising the sum of sixty-seven pounds, which may be considered as quite a fair price. The most recent information on the genus will be found in Burckhardt's paper on some remains which have reached Berlin from Sirabé, and here the pelvis, the upper portion of the metatarsus, and the immature metatarsus have been made known for the first time. A metatarsal of a large eagle has been found with the remains of hippopotamus at Ambolisatra.

REPTILIA.—In the May number of the *Geological Magazine*, Mr. R. B. Newton described and figured portions of a rostrum and mandible of a crocodile from the Jurassic rocks of Andranosamonta. This fossil, which was obtained by the Rev. R. Baron, has been named *Steneosaurus baroni*. It was associated with mollusca, referable to *Mytilus* (near *M. tigrensis* from Abyssinia), *Modiola*, *Perna*, and *Trochactæonina*; and since the occurrence of this genus was, in our imperfect knowledge, limited to European areas, the discovery is of the highest importance in questions of geographical distribution.

Remains of the huge land tortoises, named by Vaillant *Testudo grandidieri*, have been lately received, and two fine specimens have been placed in the Palæontological galleries of the British Museum.

In Mr. G. A. Boulenger's "Catalogue of Snakes in the British Museum" (Natural History), vol. i. (1893), information will be found regarding the Madagascar forms; and the book itself will be found invaluable to anyone studying Ophidia.

PISCES.—Dr. Sauvage published in 1891[2] the description of the fishes from Grandidier's collection, and this text, with the two volumes of plates issued in 1887 and 1888, completes our present knowledge of the group.

MOLLUSCA.—The Rev. A. H. Cooke, dealing with the distribution of the mollusca in the Malagasy Region, notes the great development of the carnivorous land mollusca, the occurrence of large numbers of true Helicidæ of great size and beauty, and the prominence of the genus *Cyclostoma*. The molluscan fauna of Madagascar, even as imperfectly known, appears to possess sufficient individuality to separate it off distinctly from that of the main-land. The Helicidæ are quite peculiar, not being found at all in the Mascarenes, Seychelles, or Comoros. They seem to be rather related to the *Acavi* of Ceylon and the *Pandæ* of N.E. Australia. Fifty-four species of *Cyclostoma* are known from the group, but are not confined to Madagascar, being distributed over Comoros, Seychelles, Mauritius, and Bourbon as well. The African *Bulimini* are represented by two species, but *Achatina* is scarce. Two groups of Bulimini (*Leucotænia* and *Clavator*) are peculiar. A single species of *Kaliella*, identical with a common Indian form, is also recorded. In the fresh-water forms unmistakable traces of Indian relationships are found. There are two species of *Paludomus*; *Bithynia* is recorded; several of the *Melaniæ* are of a type common in the Indo-Malay Region, while the *Melanatriæ*, quite peculiar to Madagascar, have their nearest affinities in Ceylon or East India. Not a single one of the characteristic African fresh-water bivalves has yet been found in Madagascar. Several African genera of gasteropoda occur, and indicate, in common with the land mollusca, as Mr. Cooke points out, that the land connection of Madagascar with Africa must have taken place, but that it occurred at an immeasurably remote period. References to recent literature are given in Mr. Cooke's paper.

INSECTA.—Since the publication of the Lepidoptera (1887) from Grandidier's collections, there have been issued three parts of his great work on Madagascar, devoted to the Hymenoptera. These contain both text and plates. A second series of plates of the Coleoptera was issued in 1890, but, in the absence of the text, the new species can only be considered in the light of manuscript names.

FLORA.—The latest information respecting the botany of Mada-

[2] NATURAL SCIENCE, vol. i., p. 152.

gascar will be found in the *Journal of the Linnean Society* for 1890. In this volume Mr. Baron gives a general sketch of the flora, dividing the island into regions, and treating of the geographical distribution. The affinities of the plants with those of America, the fruits, cereals, and vegetables, garden trees and shrubs, are all treated of by Mr. Baron, who also gives an appendix of introduced plants. Mr. J. G. Baker contributes to the same volume descriptions of 160 new species collected by Mr. Baron, of which four belong to new genera. A fourth part of Grandidier's great work, dealing with the plants, was issued in 1892, but the foolish practice of issuing plates without text makes this publication of little value at present.

The Mosses and Hepatics are treated of by Stephani, who publishes technical descriptions, with figures of new species.

Geology.—The geology of Madagascar is best known from the researches of Cortese and of Baron. Cortese supplies a map of the whole island, while Baron deals only with the northern half. Roughly speaking, a line drawn from north to south, and dividing the island longitudinally, shows a granitic and a volcanic area on the right side, and a Secondary, Tertiary, and Recent area on the left side. The crystalline area consists of granite, gneiss, syenite, diorites, amphibolites, and basalts; the sedimentary series, by their included fossils, representing the Jurassic, Upper and Middle Cretaceous, Nummulitic series, and Recent deposits. Much blown sand occurs round the coast, and numerous old lake basins are found, one of which, according to Mr. Baron's map, must have been nearly 300 miles along. It is to these old lake basins that we mainly look for evidences of the ancient fauna of Madagascar. The petrological characters of the rocks have been described by Cortese, while Hatch has dealt with those specimens brought to England by Baron. For general information on the fossil fauna, see Newton's two papers, quoted below, with the references therein contained; and a paper of Stanislas Meunier in *La Naturaliste*, for Aug. 1, 1893. In this last paper figures are given of several Cretaceous oysters from Mahamayo, recently received from M. Gautier, and some general notes on Malagasy geology are appended.

Geographical and Zoological Relationships.—The observations of Mr. H. O. Forbes, which include Madagascar, and of which the essence was given in this Journal for July, may be compared with those of Rütimeyer "Ueber die Herkunft unserer Thierwelt" (4to, Basel und Genf, 1867), and with those of Emile Blanchard, "Les preuves de l'effondrement d'un continent Austral pendant l'âge moderne de la terre" (*Comptes Rendus*, vol. xciv., 1882, pp. 386 and 395); while much general and particular information will be found in Dr. Blanford's address to the Geological Society, and in his review of Boulenger's "Catalogue of Snakes," in *Nature*, Aug. 3, 1893.

Hans Gadow, in the last number of Bronn's "Klassen und Ordnungen des Thierreichs" (vol. vi., pt. 4, 1893), has some observations on the geographical distribution of the Ratite and rail-like birds.

REFERENCES.

1. **Baker, J. G.**—Further Contributions to the Flora of Madagascar. *Journ. Linn. Soc.* (Bot.), vol. xxv. (no. 171), 1889, p. 294.
2. **Baron, R.**—The Flora of Madagascar. *Journ. Linn. Soc.* (Bot.), vol. xxv. (no. 171), 1889, p. 246.
3. ————.—Notes on the Geology of Madagascar. *Quart. Journ. Geol. Soc.*, vol. xlv., 1889, p. 305.
4. **Blanford, W. T.**—Anniversary Address, 1890. *Quart. Journ. Geol. Soc.*, vol. xlvi., 1890, Proc. (Madagascar, pp. 87-99.)
5. **Burckhardt, R.**—Ueber Æpyornis. *Palæont. Abhandlungen*, n.f. vol. ii., pt. 2, 1893.
6. **Cooke, A. H.**—On the Geographical Distribution of the Mollusca of the Malagasy Region. *Conchologist*, 1893, p. 131.
7. **Cortese.**—Appunti geologici sull' isola di Madagascar. *Bol. Com. geol. Ital.*, 1888, nos. 3 and 4, p. 103.
8. **Grandidier.**—Histoire Physique, Naturelle et Politique de Madagascar:
   vol. x., Mammifères, by Milne Edwards and Grandidier, 1890, pls. 123-172 (all Lemurs), no text.
   vol. xvii., Poissons, by Sauvage, 1891, 544 pp. (Plates issued 1887, 1888.)
   vol. xx., Hymenoptera, by H. de Saussure; Formicides, by A. Forel (3 parts dated 1890, 1891, 1892).
   vol. xxii., Coleoptères, by Kunckel d'Herculais, 1890, pls. 26-54 (no text).
9. **Hatch, F. H.**—On the Petrographical Characters of some Rocks collected in Madagascar. *Quart. Journ. Geol. Soc.*, vol. xlv., 1890, p. 340.
10. **Major, Forsyth.**—On *Megaladapis madagascariensis*, an extinct gigantic Lemuroid. *Proc. Roy. Soc.*, 1893.
11. **Newton, R. B.**—Notes on Fossils from Madagascar, etc. *Quart. Journ. Geol. Soc.*, vol. xlv., 1889, p. 331.
12. ————.—On the Discovery of a Secondary Reptile in Madagascar, etc. *Geol. Mag.*, 1893, May, p. 193.
13. **Renauld, Cardot, and Stephani.**—Musci exotici novi vel minus cogniti. *Bull. Soc. Botan. Belge*, vol. xxx., 1892, p. 181, and vol. xxxi., 1893, p. 100.
14. **Stephani.**—Hepaticæ Africanæ. *Hedwigia*, 1892, p. 198.
15. **Voeltzkow.**—Von Beseva nach Soalala. *Zeitschr. Ges. Erdk. Berlin*, 1893, no. 2, p. 137. [A general account of the Western district will be found in this paper.]

C. DAVIES SHERBORN.

IV.

The Interlocking of the Barbs of Feathers.

THE exquisitely beautiful, and remarkably modified epidermal products, which we know as feathers, have probably received more attention than any other form of clothing in the animal kingdom. Science, Commerce, Poetry, Art, and Fashion have each in turn laid them under contribution, a fact which, it will be readily admitted, has been beneficial to all but those most immediately concerned—their possessors, the birds.

Now we have just implied that feathers are structures with which the world in general is tolerably familiar. To a certain extent this is true; nevertheless, I have ventured to present the readers of NATURAL SCIENCE with what I hope will prove a concise account of the mechanism, by which the characteristic unity and elasticity of the vane of a typically perfect feather is secured, believing that this will be received not altogether as stale news. I wish it, however, to be distinctly understood that, for the most part, what I have to say will be found little else than a restatement of a tale already told, though in one or two somewhat minute points my claim to originality will, I believe, be allowed to pass unchallenged.

Before, however, proceeding to the more special subject of this article, it may be well to direct attention briefly to the accompanying diagram of a feather. (Fig. 1.) There may be noted (1) the strong pliant *scapus* or stem (*Sc.*), divided for convenience sake into two parts, (α) a *rhachis* (R_1) or distal, and (β) a *calamus* (C.)—commonly called the quill—or proximal portion, and (2) the *rami* or *barbs* (R^1), lanceolate processes, seated in two rows, one on either side of the rhachis, and pointing to the tip of the feather. The interstices between the rami, it will be observed, are filled by exceedingly numerous and very small processes, looking to the unaided eye in the natural feather more like bristles, perhaps, than anything else; these are the *radii* or *barbules* (R.), and it is mainly with these that we have to deal in explaining the structure of the *vexillum* (V.) of a feather. The vexillum, it must be remarked, is the compact, well-knit, elastic fringe or web ("beard" as it is called in German), composed of rami and radii interlocked in a manner to be described presently.

It has just been remarked that the interstices between the rami

are filled up by exceedingly small processes called radii; of these, there will be found two rows to every ramus, one directed towards the tip of the feather—the distal series—and one looking towards its outer or inner edge, as the case may be, and neither to the tip, nor the base of the feather, as has been described. Now if we press a sharp knife along the edges of one of these barbs, we shall succeed in getting a number of radii of two quite distinct varieties, though they have this much in common, both may be likened to lamellæ which have undergone the process familiarly known as "warping," in a longitudinal direction. Those of the distal series (Fig. 4) are found to be lamellate for about half their length, when the lamella might be imagined to have been cut up into a number of long, slender, filiform processes, some of which are hooked at the tip. If hooked, they are called *hamuli*, otherwise they are commonly known as *cilia*. The hamuli are confined to the ventral edge of the radius, but the cilia may occur on both dorsal and ventral edges.

The radii of the proximal series will be found, in addition to the warping, to have their upper edges folded somewhat sharply over towards the hollow surface, as in Fig. 3. After rather more than half of its length, this edge gives place to a series of notches, which soon—rapidly diminishing in size—blend with the almost and often quite filiform tip, into which the distal moieties of these radii are produced. It must here be noticed that, in the region of the notched edge, the radii are bent at a slight angle upon themselves, the bent ends being closely approximated, as shown in the figure.

So much for the general conformation of the radii. What is the reason for this warping? and what is the actual method of interlocking? are questions that my readers will here naturally ask.

Probably a glance at Fig. 2 will explain more than could ever be done by mere description. Here we have a semi-diagrammatic representation of an oblique section across two rami (R), taken parallel with the distal radii, or what amounts to the same thing, parallel with the shaft of the feather (P). As I have hinted, the figure tells its own story, but I should like to draw attention to the following details.

It will be observed in Fig. 2 that the proximal halves of the distal radii appear as flattened, overlapping laminæ, which at about the middle of their length suffer a sudden twist in a vertical direction, then breaking up into the hooklets and cilia previously described. These hooklets, it will be seen, are thrust down between the scroll-like upper margins of the proximal series, between which there is only just room enough to allow the hooklets to pass. The proximal radii are somewhat puzzling, perhaps, because seen in section; this, however, is unavoidable, as a reference to the diagram, Fig. 1, will, I think, make clear. The true relation of this series having been grasped, there is little else to note for the moment, except the folded upper edge, whose function is obviously to afford a secure hold to the hooklets, just

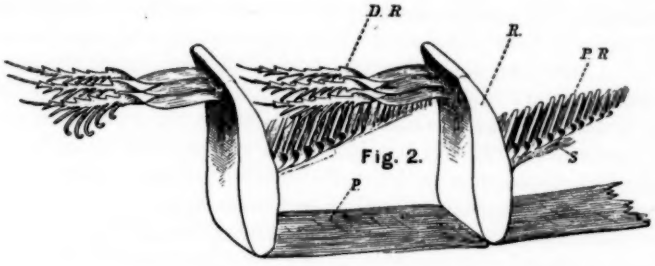


Fig. 2.

Section through 2 rows parallel to the distal Radii.

D. R. Distal Radii. P. R Proximal Radii.

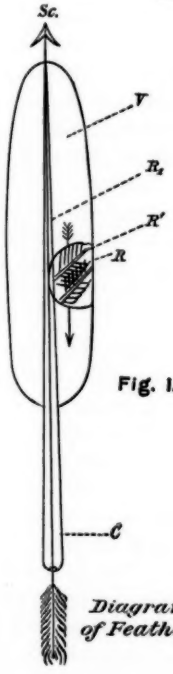


Fig. 1.

Diagram of Feather.

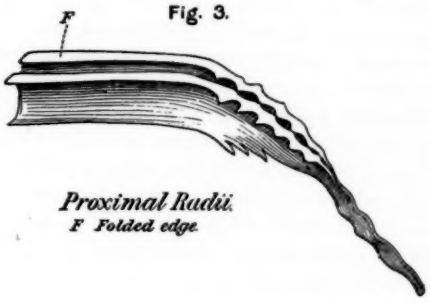


Fig. 3.

Proximal Radii.
F Folded edge.

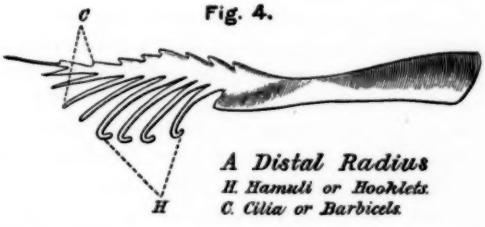
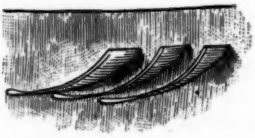


Fig. 4.

A Distal Radius
H. Hamuli or Hooklets.
C. Cilia or Barbicels.



Section through the bases of 3 Distal Radii

Fig. 5.

Fig. 6.

Magnified Section through a Hooklet and folded edge of a Proximal Radius.

F. Folded edge.
H. Hooklet.

DIAGRAMS OF FEATHER-BARBS.

described as being thrust down between them; and the formation of comparatively deep channels by the approximation of their lower edges. These channels are not maintained far, if at all, past the most proximal hooklet; from this point, it will be seen, these sectionised radii diminish in size, terminating close against the surface of the next ramus.[1] Now it only remains for the reader to draw upon his imagination, to see at once that a comparatively severe strain would have to be exerted upon the rami to pull them apart, and if he will only make the experiment on some large quill feather, he will be amply satisfied; then let him sever a few rami at their base, and see how easy it is to separate them by pulling the ends in opposite directions, the hooklets, of course, gliding along the grooved edges.

Now a word as to the "warping." The radii of both distal and proximal series are, it will be remembered, longitudinally curved, or "warped," as I have termed it, but in Fig. 2 the radii have the appearance of *flattened* not curved laminæ! How is this? Well, I have chosen to give the appearance they present under the microscope when seen *in situ*, rather than avail myself of the licence allowed me in adopting a semi-diagrammatic figure, for the sake of those who take up this work for the first time; for unless seen in section, it is difficult, if not impossible, to consider these anything but what they appear—flattened lamellæ, seated obliquely along the ramus, and even examination under high powers does not reveal the true state of things. Their actual form appears in section as in Fig. 5, which represents three radii cut off close to their base.

As touching the "channels" of the proximal series, what we have now to do is not so much to tender a reason for their formation—this being rather too presumptuous, as to offer a suggestion to that end. The first thing that will occur to the thoughtful reader is, if these edges were free, and directed straight downwards, might they not be a source of danger to the hooklets, inasmuch as the latter would perhaps frequently catch their lower instead of their upper edges; while the present arrangement suggests a twofold purpose: firstly, to afford a wind-proof surface for the downstroke of the wing (in the case of the remiges and flight feathers), thus preventing the displacement of the hooklets by the upward rush of air; and, secondly, to conduce to that marvellous elasticity of the feather we paused to admire in the earlier part of this paper, the hooklets gliding freely over the smooth, hollow surface, yet with difficulty letting go their hold. Surely, there seems to be good reason for these views. At any rate, just such an interpretation as this seems to find favour with so good an authority as Dr. Gadow. I find on reference to his most valuable work the following remarks, which, by the way, however,

[1] These diminished portions, it should be noted, are the distal ends of radii arising nearer the proximal end of the ramus. A moment's reflection will show—bearing in mind their oblique direction—how, that being placed one in front of the other, the sections will gradually decrease.

leave us in a little uncertainty as to whether the full extent of the curvature of the radii is appreciated or not. Thus (quoting Klee) he says, "Ihr *oberer Rand*[2] ist einfach umgeschlagen, wodurch längs dieses Randes eine vollkommene Rinne zu Stande kommt, die unter dem Mikroskop allerdings den Eindruck eines verdickten Randes macht." And again, speaking of the elasticity of the feather, he says, "Zugleich ist die Fahne in höchsten Grade elastisch, nicht nur durch die Elasticität aller einzelnen Federtheile, sondern weil die Hacken auf den glatten Strahlen *Kanten*[2] hin—und hergleichen können."

The relative position of the radii, like their form, varies. Both distal and proximal rows may arise from what would otherwise be the ridge of the ramus, or the distal radii may arise from the upper border of the ramus, while the proximal may run along quite near the lower border. Frequently the distal radii are overhung by a projecting ledge, formed by the much compressed ridge of the ramus, and between these every possible gradation may be found, according as the part examined be from the primaries, secondaries, or coverts, or from the inner or outer margins of the vexillum.

Along the lower edges of the rami in Fig. 2 will be noticed a thin transparent band (P) of a width corresponding to the section. This I recently found in the remiges of a Teal, *Querquedula crecca*. The free edge may be either closely approximated to, or even fused with, the lower edge of the next ramus. To the naked eye, this appears along the side of the shaft as a narrow band of silvery whiteness, and very smooth, but I am at a loss to account for its function, and do not care to hazard a guess. I have indicated the presence of a similar band under the proximal radii; it seems, however, to occur but rarely. Mr. R. S. Wray, to whom we shall have occasion to refer presently, makes mention of such a band in his paper, shortly to be noticed.

I propose now to present a sort of census of opinion as to how the "Interlocking of the barbs of a Feather" was obtained; but, to be brief, it will be well to confine attention to the descriptions of some three or four writers whom we may consider to have been more or less well-qualified to speak on this subject. This will carry us back some sixty years, to the time of the great Nitzsch, the father of the science of Pterylography. His description was fairly accurate; the wonder is it was not quite so. He perceived that the radii could be divided into two series—an anterior and a posterior, as he called them, but he failed in his endeavour to explain their mutual relations, considering that the hamuli of the anterior radii were for the purpose of catching into "little pits" prepared for their reception in the proximal radii. Burmeister, editing Nitzsch's work a few years later, exploded this theory, and gives essentially a correct explanation. He says, "I have noticed in all parts a strongly-thickened, superior margin of such a size that the hooklet can just grasp it. It is behind this margin . . . . that the hooklets take hold."

[2] The italics are mine.

Owen, writing some thirty years later, gives a much less truthful description. He says, "The barbules arising from the upper side of the barb, or that next the extremity of the feather, are curved downward or toward the internal surface of the shaft; those which arise from the underside of the barb are curved in the contrary direction; so that the two adjoining series of hooked barbules lock into one another in a manner which has been compared to the fastening of a latch of a door into the catch of a door-post."

Huxley's description is as follows:—"The barbules may be laterally serrated and terminated by little hooks which interlock with the *hooks*[3] of the opposed barbules."

The last and most authoritative account is that of the late Mr. R. S. Wray. Practically, his paper, short though it is, tells us all that is to be told; but the author presumably failed to appreciate, or missed entirely, one or two of those nice little differences that will so often escape the notice of the most painstaking workers, of whom he was one. Possibly "'tis a rule in Nature," in order that those who come after us may have something left to do.

As just stated, Wray's figures and descriptions may be held in all but a few details to be correct. Exception is taken to his interpretation of the proximal radii. These he describes as ". . . thin laminæ, with a thickened upper edge forming a small ledge or kind of flange"; and continues, "If a single barb be examined, the proximal barbules appear . . . at their proximal end to join on to an edge-piece running parallel to the barb . . . this edge is seen to be formed by the attenuated halves of these barbules overlapping one another, and being turned at a considerable angle upon the other half." On referring to his figures, however, we find these barbules represented as perfectly flat laminæ, vertically inserted by their base along the ramus, and with a slight "flange" running along the upper edge, but with no trace of the "attenuated halves overlapping one another." True, this is a diagram, but surely it would have been more correct to figure the specimen, since the essence indeed of a diagram is to give us *the* points of a structure, divested of all superfluous detail. So far as my experience goes, this edge-piece occurs but rarely, neither do I believe it is formed as Wray imagined it, since, in the only case in which I ever found it, the radii were normally related, "the edge-piece," though closely approximated to, being yet quite distinct from them. While this was in the Press I detected a precisely similar flap under the *distal* radii. Again, as touching the notches, these are accounted for by supposing that they are for the purpose of allowing the distal portion of the radius to be turned upon itself without "crumpling." Would it not seem more probable that these notches are—if we are to explain their presence at all—rather to keep the edges of these radii sufficiently far apart to allow not only of the passage of the hooklets, but to prevent their

[3] The italics are mine.

being injured by chafing when in position. The curvature does not seem sufficiently great to account for these notches in the first place, and in the second, seeing that the curve is not delayed till the radius has completed its development, and is then suddenly bent, but that the curvature is synchronous with growth, a far greater inflection could have taken place without any special arrangements, as witness a thousand instances in Nature. Lastly, I would point out that the proximal radii, instead of curving abruptly just at the point where the laminæ of the distal radii break up into hooklets, as shown in Wray's figure, are actually not only curved less, but, as already pointed out, extend right across to the next ramus. I have purposely dwelt upon the shortcomings of these figures, because they are rapidly making their appearance into the various text-books. Though this is a fact to be deplored, it may be readily understood. I suppose, nowadays, if one finds himself engaged in bookmaking—of the more honourable kind, I mean—he must add yet more drudgery to his labours, by verifying every statement to its minutest details, when probably, by the time he has finished the last chapter, he will have to begin again and bring his work "up-to-date."

REFERENCES.

1. **Nitzsch, C. L.**—System der Pterylographie. Halle, 1840. English translation, Ray Soc., pp. 10, 11 (1867).

2. **Owen, R.**—Anatomy of Vertebrates, vol. ii., pp. 231, 1866.

3. **Huxley, T. H.**—The Anatomy of Vertebrated Animals, p. 235 (1871).

4. **Wray, R. S.**—On the Structure of the Barbs, Barbules, and Barbicels of a typical Penmaceous Feather. *Ibis*, pp. 420–23, pl. xii. (1887).

5. **Gadow, H.**—Bronn's Klassen und Ordnungen des Thier-reichs, iv. Abtheilung. Theil i., p. 528 (1886).

W. P. Pycraft.

V.

The Lucernarians as Degenerate Scyphomedusæ. A Note upon the Phylogeny of the Order.

PRELIMINARY.

BEFORE entering upon discussion of the problem of the descent of the Lucernariæ, it may be well to set out for the guidance of the general reader the more important facts already known concerning the class to which they belong.

The Hydrozoa, in which together with the Zoophytes, Jelly Fishes, and Siphonophores they find place, is conveniently grouped in two divisions (2). The first includes the Lucernarians themselves, together with those fleshy Medusæ or jelly fishes without velum (hence sometimes called "acraspedote medusæ") and with eight marginal sensory organs (tentaculocysts) so well-known under the forms of *Aurelia*, *Pelagia* and *Rhizostoma* (termed collectively Discomedusæ), and finally the Conomedusæ, a small group with four tentaculocysts and with a velum—*Charybdæa* being the type. Such sub-class comprising these orders constitutes the Scyphomedusæ, so called on account of the general presence of a particular stage in the life-history of typical species. Normally this is as follows:—A ciliated embryo (proceeding from the sexual or medusa stage) after a short period of free-swimming pelagic existence, settles down and becomes attached to some stationary object by one end. A mouth forms at the other, around which sixteen finger-like tentacles appear; and at the same time the lower part of the body becomes drawn out into a stalk.

This elegant form, $\frac{1}{16}$ to $\frac{1}{8}$ inch in height, is the *scyphistoma* stage, and is what is sometimes termed the hydriform phase, from its general resemblance to the fresh-water polyp, *Hydra*. Soon, as growth goes on, food being captured by the transient tentacles, transverse constrictions—*strobilation*—cut the body into a rouleau of discs, appearing thus as a tiny pile of sculptured plates. Each disc has eight arms, bearing each a tiny tentaculocyst at the tip. This is the *strobila* condition, and the discs composing it, as the constrictions become deeper, are, one by one, broken off and sent out on a free-moving life. Known at this period as *ephyræ*, these organisms rapidly take on the form of ordinary jelly-fishes, develop sexual organs, and

send out swarms of ciliated embryos to go through the same strange cycle of life.

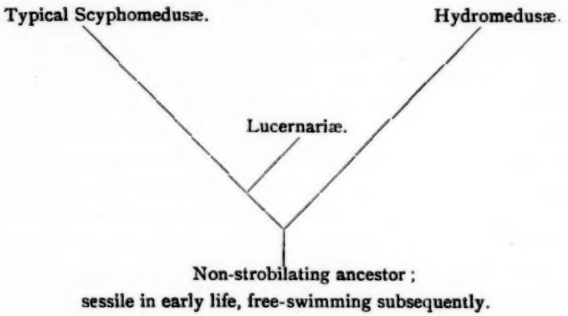
The second great division of the Hydrozoa, viz., the Hydromedusæ, is, by most authorities, made to include both those fixed colonial-living polyp forms, known generally as the Hydroid Zoophytes, as well as the highly-specialised and complex floating siphonophores exemplified by *Physalia*, the Portuguese man-o'-war. The former—the Hydroid Zoophytes—which alone we need mention here, have a life-cycle closely akin to that of the Scyphomedusæ, the main difference being that the fixed stage—the hydriform—does not give origin to medusæ by transverse constriction, but, by oft-repeated budding, produces usually large tree-like colonies. A medusiform sexual stage is, however, present, though its importance is overshadowed and masked by the great development of the hydriform. Thus such a typical Zoophyte as *Obelia gelatinosa* forms, by repeated budding from a ciliated embryo which has become fixed, a large colonial arborescent community of many hydra-like and purely nutritive polyps. Later on, certain modified organs produce, *by budding*, numerous tiny medusæ, which break loose, and float away as beautiful glassy, pulsating bells. These differ from the medusæ of the Scyphomedusæ in having a muscular membrane—*velum*—closing, all but for a central opening, the mouth of the bell, hence the term "craspedote medusæ." This stage is sexual, and gives rise to free ciliated embryos.

The Scyphomedusæ have internal or gastral filaments, and their hydriform stage is simple; the Hydromedusæ have no gastral filaments, and their hydriform stage is colonial and frequently complex. The Lucernarians possess the two former characters, and for these and some less easily stated reasons, their intimate relationship with typical Scyphomedusæ is universally admitted. They, however, differ from both divisions in that their life-cycle is not complicated. The adult hydriform animal gives rise directly to ciliated embryos, which settle down and become of the adult form without metamorphosis.

Several species of Lucernarians are found in British seas. The most common in the South (English Channel) is *Haliclystus octoradiatus*, a most elegant, short-stalked, bell-shaped species found almost invariably attached by an adhesive disc to blades of the sea-grass (*Zostera*) close to low-water mark. The edge of the bell is drawn out into eight points, each bearing a cluster of short clubbed tentacles, well provided with stinging cells. Midway between each two groups of tentacles is a hollow papilla, the "colleto-cystophore," usually believed to be the equivalent or homologue of the tentaculocysts of the medusæ. Normally, these are eight. A like number of genital bands extend from the mouth into each of the marginal points. In general outline *Haliclystus* resembles a shortly pedicelled inverted cone with scolloped margin worked into eight projecting tentacle-armed points. The size frequently reaches 1 in. in height, by 1¼ in. across.

NEW CONCLUSIONS.

The position assigned to the Lucernariæ (=Calycozoa) has long been that they represent, comparatively but slightly modified, a simply organised ancestral form of those Scyphomedusæ called by Haeckel and Lankester the Discomedusæ. This view was embodied by L. Agassiz in the comparison of the relation borne by the order to the Discomedusæ, to that which the stalked Crinoids (primitive form) bear to the free-moving Comatulidæ. This meaning is expressed in the following "tree," which gives the accepted view:—



Such pedigree has the excellent advantage of simplicity—a lowly-organised animal being placed as the common ancestor both of complex and of, presumably, little changed, simply organised descendants.

Quite recently some slight observations (4), which I recorded in the July number of NATURAL SCIENCE (p. 33), decided me to examine afresh into the truth of this conclusion, with the result that new evidence points distinctly to a completely different phylogenetic arrangement, whereby the Lucernariæ would appear to owe origin to an ancestor having as complex a life-cycle as, say, such a typical Discomedusid as *Aurelia* has at the present day, and *not* to a simple non-strobilating scyphistomatous type of animal.

This origin, I believe, came about by the premature development of genital products during the scyphistoma stage of the ancestral form. When such hastening of events took place—ova and sperm being formed and set free prior to strobilation—the latter phase would in consequence be rendered abortive, no ephyræ would be thrown off, and no medusid stage would occur. Such a change in the life-cycle would clearly be advantageous, as under sessile conditions of life competition with free-swimming medusæ would be avoided, and thus the variation resulting from premature sexual maturity would tend to be repeated, and finally to be perpetuated. This same avoidance of competition with the Discomedusæ accounts for the non-operation of that most general law of Natural Selection —that when through advantageous variation a new species is evolved, the old or stock species is forced from the field and becomes

extinct, since it cannot compete for long *in the same sphere* with the better equipped varietal form.

The clue that led me to this conclusion as to the phylogeny of the Lucernariæ was the fact of finding great and remarkable variation or inconstancy in *Haliclystus octoradiatus* in those bodies termed colleto-cystophores, and which are generally supposed to be homologous with the marginal organs—tentaculocysts, etc.—of the medusæ. Such variation consists, as I have recorded elsewhere, (*a*) in duplication of the organ, (*b*) in the frequent suppression of one or more in the same animal, (*c*) in the still more frequent reversion in structure to that of the form of the normal papillæ or tentacles as seen in the marginal clusters of these appendages. This gives us the fixed fact of *great variability in the marginal bodies*. Now inconstant presence and frequent reversion are known to be the accompaniments of a vestigial organ; hence we conclude that these bodies are vestigial, consequently have been more important than they now are, and that the origin primitively was from marginal tentacles. As bearing upon this, it is important to remember that it is admitted generally that tentaculocysts arise from modification of ordinary tentacles.

These facts bring us now to the conclusion that *Haliclystus* is descended from an animal possessing a stage wherein certain marginal tentacles had become modified into highly important sensory organs, approaching, if indeed not almost similar to, the tentaculocysts of medusæ. Further, organs of this complex description can scarcely be imagined as in any way serviceable to a sedentary animal unprovided with powers of locomotion, whatever use such may subserve in a free-swimming organism, whether we follow the old theories adducing auditory and visual functions to these sense-organs, or follow Dr. Hurst's more probable theory as put forward recently (3). Sessile animals of the description of the Lucernariæ can neither follow prey nor avoid capture, and hence do not require auditory and visual organs, much less automatically-actuated direction-controlling bodies.

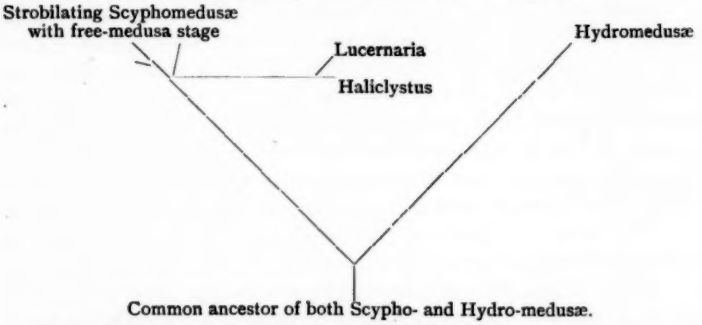
This brings me back to my initial proposition, that among the ancestors of *Haliclystus* was a form having a strobilation stage throwing off ephyræ, which became acraspedote medusæ provided with eight marginal sensory organs and with numerous tentacles separating these, approaching indeed such a form as the present-day *Aurelia*. Then, when the premature development of sexual glands occurred in the scyphistoma stage, as already mentioned, it is reasonable to infer that the other organs belonging normally to the fully-developed adult form (acraspedote medusa) would also appear. Chief among these would be the marginal sensory bodies; but these would occupy a very different platform to the sexual glands. The latter are necessary to the existence of the animal; the former—under the changed conditions of *sexual maturity in sessile position*—would be of no more use, as pointed out above. The courses open to them must either be, (*a*) reversion to the original form, *i.e.*, that of marginal tentacles, (*b*)

adoption of a new function, or, (*c*) disappearance. As we have seen, the first and third of these alternatives take place frequently in *Haliclystus*, which, perhaps, more than any other Lucernarian remains most closely related to the old form.

In some species, however, *e.g.*, *Lucernaria campanulata*, the third alternative has been unmistakably adopted, accompanied, too, by the very significant fact that, though absent in the adult, yet the marginal bodies do exist for a short period in an early stage of life. (It may be that the genus comprising this species is directly descended from *Haliclystus*.)

As to the second alternative—the adoption of a new function—probably in *Haliclystus* there is indeed a secondary one coming, or come, into operation. In this genus, the marginal bodies are used, apparently, as accessory to the ordinary tentacles in holding on to any prey in course of capture. Thus, if with a pencil point one of the marginal bodies be touched, it adheres strongly to the pencil, and with very perceptible power. Coincident with the loss of sensory organs, there has been decay of the whole nervous system, the purpose for which departed with the cessation of rhythmic motion and the lost utility of the tentaculocysts.

The view I have above put forward as to the relationship and descent of the Lucernariæ is expressed in "tree" form as follows, and shows clearly on comparison with the diagram given at the commencement wherein the divergence from the old view consists :—



Dr. Hurst has arrived independently and simultaneously at conclusions which, I believe, are practically the same as above put forward, but as I know but the outlines of his reasoning, the reader is referred to his article on the subject following this (pp. 209–217).

REFERENCES.

1. **Agassiz, L.**—Contributions to Nat. Hist. of the U.S. of America, vols. iii. and iv. Boston, 1862.
2. **Lankester, E. Ray.**—Encyclo. Brit. article Hydrozoa.
3. **Hurst, C. Herbert.**—Biological Theories, V. NATURAL SCIENCE, vol. ii., part 16.
4. **Hornell, James.**—Abnormalities in Haliclystus. *Ibid.*, vol. iii., part 17.

JAMES HORNELL.

VI.

Biological Theories.

VI.—THE PHYLOGENY OF LUCERNARIANS.

THE following speculation is now published, not only on account of the intrinsic interest of the question suggested by the title, but also as an illustration of the application of various views, already published in this series of essays, to the solution of one definite problem; and I have deliberately chosen a case in which the conclusion arrived at is the direct opposite (or converse) of the view to be found in most modern zoological works which treat of the subject. I have made this selection in order that anyone who is prepared to give my views a fair test may do so by comparison of my result with that reached by the usual methods and on the usual assumptions.

As it is necessary, in the course of the argument, to make use of at least six views not as yet familiar to zoologists in general, I will begin by enumerating those views, giving references to the papers in the earlier volumes of NATURAL SCIENCE where fuller accounts of them may be found.

1. Heredity is a mere similarity or likeness among corresponding individuals belonging to several generations of one species. It is not a force or other objective influence, simple or complex, capable of producing effects. The likeness between father and son is not the effect of heredity; it is heredity itself (vol. i., p. 502).

2. This similarity among individuals, or if we prefer to call it so, this constancy of structure in successive generations, is the result of Natural Selection. It is not simply an effect produced once for all, but is dependent upon the continued action of Natural (or other) Selection for its maintenance. Natural Selection under constant environmental conditions tends steadily towards the production of a constant structure, which, when it has become almost constant, we speak of as the specific structure, and the constancy of which may be called "heredity," though the abuse of this term makes it safer to use only the term "constancy" (vol. i., p. 578).

3. Natural Selection is therefore, in a certain sense, independent

of "heredity," and is older than "heredity," and has led to the evolution of "heredity" from "variability," or to adopt the safer terms, the evolution of constancy from inconstancy. Inconstancy is the older: constancy which is never complete is only inconstancy kept within narrow limits by the continued action of Natural Selection. The assumption that "heredity" occurred *ab initio*, and that "variation" has been produced by various external agents—Lamarckian and others—is a mistake (vol. i., p. 580).

4. The ontogeny of an individual, though in some cases it presents a marked resemblance to the real or supposed phylogeny of the species, with reference to certain characters, usually shows only a very slight such resemblance, and may show none at all. We are, therefore, not justified in relying upon it as a "record" of the phylogeny, even though we admit that the supposed record is highly imperfect. Von Baer's law is readily verified in some cases at least; and while it appears to contain all that is true in the "Recapitulation" Theory, it is contradictory to the rest of that theory (vol. ii., pp. 197 and 365, and especially 368).

5. The resemblance between an adult animal on one hand and the larva of another species on the other hand, while indicating a close relationship between the two species, does not show that the second is descended from the first. A stalked crinoid may resemble the immature form of a free-swimming one, and the latter may be actually descended from a form very like the former, but the resemblance in question does not *alone* justify this conclusion, inasmuch as the same resemblance might have arisen from a relationship the direct reverse of that supposed (*Locc. citt.*) The following essay treats of a case in which this reverse relationship appears to be very near the true one.

6. Tentaculocysts cannot subserve an auditory function; and such a function would be useless to a medusa if they could (vol. ii., p. 353, last paragraph); but they may and probably do serve a function of the utmost importance in the preservation of jelly fishes from destruction by oceanic waves (vol. ii., p. 421).

While writing the essay last referred to, the following question occurred to me with almost maddening persistency:—*Haliclystus has tentaculocysts or something of the kind and does not swim: can it then be that the function suggested is the true one, seeing that such organs are present also in an animal, to which such a function would be useless?*

It was not till I had answered that question in my own mind that I ventured to publish the above-mentioned view on the "true function of tentaculocysts." The reason for withholding my answer till now will appear later.

The structure of the marginal bodies of *Haliclystus* (*Lucernaria*) *octoradiatus* shows that they are unfitted for the performance of the

function which I have ascribed to tentaculocysts. In position, however, these bodies correspond exactly with the rudiments[1] of the tentaculocysts in a scyphistoma.

The function of the tentaculocyst-rudiment, supposing it to have only one function of importance, is to develop into a tentaculocyst. The development in such forms as I have examined (and have failed to identify!) is direct, and exhibits nothing which justifies the assumption that they have any specially "larval" function, or function not connected with the production of the adult organ: and though we may be unable to say at what precise stage they come to be capable of performing the "tentaculocyst-function," I think we are justified in believing that the efficient performance of that function after the organ is fully developed may reasonably be regarded as the chief factor which has determined the evolution of these organs under the guidance of Natural Selection.

Considering the resemblance in form, and, to a certain extent, in structure, and the identity in position of these rudiments on one hand, and of the marginal bodies of *Haliclystus* on the other, a community of origin is hardly doubtful; in other words, the influences (or some of them) which have determined, or helped to determine, the presence and the structure of either may reasonably be supposed to have played a part in the case of the other also.

According to the usual view, the Lucernarians are the unmodified, or little-modified, descendants of the common ancestor of Scyphomedusæ in general. This view further suggests that *Lucernaria* is the "most primitive," and that *Haliclystus* is "higher" or more modified; and that all free-swimming medusæ (Scyphomedusæ only, I mean, of course) are descendants of forms which, like *Haliclystus*, exhibited no "alternation of generations"—no strobilation, while remoter ancestors still were very similar indeed to *Lucernaria*. Such a view is an almost necessary consequence of the Recapitulation Theory.

For convenience, I will now use the names *Lucernaria* and *Haliclystus* a little loosely, so as to include all hypothetical ancestors possessing the distinctive characters of these genera.

The orthodox view just set forth brings us face to face with a problem which presents, I believe, insurmountable difficulties, *i.e.*, how to account for the evolution in *Lucernaria* of marginal bodies so as to give rise to *Haliclystus*.

We must, in attacking the problem, assume either—(1) that the

[1] I use the term "rudiment" in its true sense, and as equivalent to the German "Anlage." Use may justify a change in the meaning of a word, but the persistent misuse of the terms "rudiment" and "rudimentary," when "vestige" and "vestigial" are meant does not appear to me to justify the change in this case, especially as we have, so far as I know, no other words to put in their place; for the German word "Anlage" is so utterly "un-English" that its adoption in English (or even American!) writings appears to be open to serious objection. I deem it best, therefore, to use "rudiment" for what it really means, and to ignore the prevalent misuse of the term, in the hope that it will soon die out.

bodies in question are useful, or (2) that the evolution has been independent of Natural Selection. Few will be willing to accept the second hypothesis—I least of all, for I believe more thoroughly in the adequacy of Natural Selection than even Mr. Wallace, to whom, with Darwin, we owe the theory itself.

If, however, we adopt the first hypothesis (provisionally), we must further suppose that a portion of the genus *Lucernaria* has been isolated—geographically or otherwise—and so protected from the action of the selection; otherwise the evolution of the new genus (*Haliclystus*) from the old one (*Lucernaria*), under the direction of Natural Selection, would, of course, involve the extinction of the old one.

Lucernaria and *Haliclystus* are, however, found in the same seas, though their geographical ranges may differ considerably. As to the geographical distribution of any one species of *Haliclystus* or of *Lucernaria*, I will not venture to speak, for I am not sure that we can yet say with certainty what are, and what are not, distinct species (or even genera) in this family. For present purposes it is sufficient that forms which have been called *Haliclystus*, and others which have been called *Lucernaria*, are found on both east and west coasts of the North Atlantic, as well as elsewhere, and that some zoologists consider that some of the American specimens in both genera are specifically identical with some of the European ones; and since the mode of life is the same in both, and both live on *Zostera*, and on red sea-weeds, just below low-water mark, there arises a very serious difficulty in the way of the assumption of isolation, either geographically or otherwise. Though the marginal bodies are, perhaps, not *very* complex bodies, yet, in comparison with the whole body of the animal, they are sufficiently complex to justify the assumption that Natural Selection could only determine their evolution during a very long and very severe struggle for existence and for multiplication.

The organs may give some slight advantage, or even a great advantage, to *Haliclystus*. They may serve, for instance, as "anchors" (Clark) (1); but that is not enough. If Natural Selection has caused the evolution of animals possessing those organs (*Haliclystus*) from animals not possessing them (*Lucernaria*), that means that the organs have at every stage in their evolution conferred such an advantage on their possessors as to enable them to vanquish, to starve out, to render extinct, the forms not possessing them, or possessing them only in a less perfect state of development. It means that the evolution of *Haliclystus* from *Lucernaria* would have exterminated the genus *Lucernaria* in the seas where this evolution occurred; and this the geographical distribution of the two genera emphatically contradicts.

We may therefore regard—nay, we are compelled to regard, the evolution of *Haliclystus* from *Lucernaria* as disproved.

From what, then, is *Haliclystus* descended?

I believe the clue to the solution of this problem is to be found in

a consideration of the evolution of tentacles, and of tentaculocysts, and of the marginal bodies of *Haliclystus*.

The evolution of the marginal bodies in *Lucernaria* offers the difficulties already considered, and, therefore, we may not take these bodies as the starting-point in speculating as to the origin of tentaculocysts. Before this procedure would be allowable, we must account for the origin of the marginal bodies themselves. As this origin is not obvious, we may consider the other organs, tentacles and tentaculocysts, first; and we will begin with tentacles, as these are the simpler. In doing so, however, it is necessary to bear constantly in mind that the more complex is not necessarily a modification of the simpler—the simpler may just as well be a modification of the more complex, or the two kinds of organs may even have been independently evolved.

The tentacle in its simplest form is a mere outgrowth of the body-wall, identical in histological structure with the adjacent portions of that body-wall. Almost in this simple form tentacles may be seen in *Hydra*, though *Hydra* is probably far from being a primitive form. A mere projection of the wall of the animal, provided it be contractile and suitably placed with reference to the "mouth," may well be regarded as useful in the prehension of food. Its usefulness would, moreover, be greater, within certain limits, the greater the length of the process. Every individual possessing such outgrowths would, therefore, be favoured thereby in the struggle for existence and multiplication; and this advantage would, moreover, always rest more especially with the individuals in which the processes were, within limits, the longest. Hence the evolution of tentacles from mere irregularities of the body-wall can be explained without any assumption beyond that of the operation of Natural Selection.

How a free-swimming medusa was evolved we are not now considering, and fortunately it is not necessary that we should answer the question at present. Suffice it to say that free-swimming medusæ exist, and that the evolution of their tentacles in the above-described way offers no difficulty.

With tentaculocysts the case is different. If we suppose them to be modified tentacles the difficulties vanish; otherwise the difficulties are, so far as I can see, insurmountable. The slow transformation of a *few* tentacles *out of many* so as to better perform a special function, performed, at best, only badly by a tentacle, leaving the remainder to carry on the original chief function of these organs, appears possible; for the chief changes required are the formation of a depression around the base of the tentacle and subsequently a shortening of the tentacle itself, and these offer no difficulty. Every stage of such an evolution provided only that the medusæ are fairly large, and becoming larger, fulfils all the requirements of the theory of Natural Selection; that is, the transformation is a gradual one, and every stage in it is an advance upon the previous one; or in other words, every supposed change in the evolution is a minute one; is one

which may well be supposed to occur "fortuitously"; and is one which confers an advantage upon the species undergoing the transformation—however numerous these species may be.

It is not necessary to go more into detail in this question, as the view here urged is, I believe, adopted almost unanimously: difference of opinion, if there be any, will probably be confined to the question of the possibility, or perhaps probability, of such a transformation occurring independently in several species.

There are, however, not a few who have only adopted this view as to the origin of tentaculocysts at a moment when they were not thinking of their homologues in a supposed *Haliclystus*-like ancestor. These, no doubt, will require that any hypothesis or conclusion as to the course of evolution of tentaculocysts shall regard the marginal bodies of *Haliclystus* (or something very like them) as having served as a stage in the evolution. To such I commend the following considerations.

(1) The evolution of marginal bodies in a Lucernarian *ab initio* offers difficulties already considered, and apparently insurmountable.

(2) The evolution of these bodies *directly from tentacles* in ancestors of Lucernarians offers difficulties no less formidable. Natural Selection will not on this assumption account for the evolution of two genera *Lucernaria* and *Haliclystus* in the same seas, and in like positions in those seas. If the marginal bodies are advantageous, then their evolution from tentacles would be accounted for easily enough, provided we had *Haliclystus* alone to deal with. The evolution of the two side by side negatives any such hypothesis.

We may therefore turn in another direction for the solution of our problem—there is only one left! The marginal bodies may be *vestiges* of the tentaculocyst-rudiments of ancestral scyphistomata.

This involves, of course, the supposition that *Haliclystus* is descended, not merely from scyphistomata, but from free-swimming medusæ.

The evolution of tentaculocysts in free-swimming medusæ I have explained. In that explanation is involved an explanation of the evolution of their rudiments in the young. The evolution of strobilating from non-strobilating medusan types appears to me to offer no serious difficulty, and I leave this portion of my argument (which seems almost obvious) to be filled in by my readers. If it should be called for I will publish it.

Given, then, that there has been evolved a type of medusa in which the formation of a scyphistoma, strobilation, and the separation of *Ephyræ* provided with rudimentary tentaculocysts have been phases in the life-history, the origin of Lucernarians from such a type offers no further difficulty of great magnitude. (*Re* the meaning of "rudimentary," *see* footnote, p. 211.)

On this hypothesis the community of origin or "homogeny" (as Professor Lankester has well called it) of the marginal bodies and the

tentaculocysts is not a mere community of origin; the marginal bodies are vestiges of the rudiments of tentaculocysts, *i.e.*, they are vestiges of tentaculocysts themselves; but what is their function? Are they *mere* vestiges, or are they organs which have undergone a change of function?

Again, the coexistence of two genera in the same localities and with the same mode of life shows the way to the answer. They are mere vestiges. The ancestral function is impossible: they cannot serve as rudiments whose function is to develop into organs (tentaculocysts) useful in a free-swimming phase, because there is no such phase in the life-history. They cannot serve a function of sufficient importance to determine their preservation through Natural Selection, for *Lucernaria* thrives abundantly without them living in the same way and in the same places. We are therefore driven to the conclusion that these bodies, if not functionless, are at least of so little value to their possessors that the chief competitor in the struggle for existence (*Lucernaria*) survives although devoid of them. If this be true, then (*see* view 2 at commencement of this essay) they *must* be inconstant ("variable") in structure, or at least must tend to become so.

Now this point seemed to be so easy to put to the test of observation that I delayed to publish this essay till I should have an opportunity of applying the test.

I had not yet had the opportunity of so testing my conclusion when the July number of NATURAL SCIENCE appeared, and in it a record of observations made by my friend, Mr. Hornell, on this very point (vol. iii., p. 33). No communication on the subject had passed between us. His observations were made in ignorance of my conclusions, and hence the element of bias is happily absent.

I should have been sanguine indeed to expect so striking a confirmation of my conclusion! Out of one hundred and eighteen specimens of *Haliclystus* taken in June last in Jersey, seventy-eight (that is, two-thirds of the whole number) exhibited a very marked abnormality in the structure of these organs, *i.e.*, some of the organs were "crowned with tentacles." Of specimens gathered earlier in the year (that is, older specimens which had lived through the winter) a small proportion possessed less than the normal number of these bodies. None were observed to be "crowned with tentacles." Either the tentacle-crowns had been absorbed, or the individuals possessing them had been worsted in the struggle for existence during the past winter.

Further observation is necessary before we can say which is the true explanation. The fact that many—about 15 per cent. in a lot I received from Messrs. Sinel and Hornell in the spring of the present year—have survived through the winter with less than the normal number of these bodies, shows at least that the possession of the full number of these bodies does not give a very great advantage, if any, to their possessors.

Some years ago I obtained from Mr. Bolton a large number—probably nearly two hundred—of specimens of so-called *Lucernaria*, which, he informed me, had been collected on the coast of Cornwall, and they were forwarded alive on some red algæ. They were all small—it was autumn—and I then noticed that they were of two kinds—*Haliclystus* and *Lucernaria*—mostly *Haliclystus*. I had not considered this problem then, and simply took them to be two genera mixed, and thought no more about it. I did not examine them closely, and hence cannot say whether intermediate forms with less than the full number of marginal bodies were present or not. The naturalists at Plymouth may well take that problem in hand and decide for us whether *Lucernaria* and *Haliclystus* are generically—to say nothing of specifically—distinct or not.

Whatever answer may be given, Mr. Hornell's description of *Haliclystus* must be enough to convince any non-evolutionist—if such a zoologist still exists—of the mutability of species (or genera). It is a simple description of a species in the very middle of its transformation—*Haliclystus* is in the very process of being transformed into *Lucernaria*, there, on the coast of Jersey!

On receiving my friend's paper I at once wrote to him, giving him an outline of the above argument, and pointing out the remarkable way in which his observations fitted in with my conclusions, and was not a little surprised to receive, by return of post, a long letter, in which he showed how he had, by an altogether different line of reasoning, come to the same conclusion as my own, viz., that *Haliclystus* is a "degenerate" scyphomedusan—an "arrested scyphistoma"—and that *Lucernaria* has gone further in its "degeneracy."

If, however, such a "degeneration" or "arrest" may occur once, it seems probable that it may occur often. There may be a well-established genus, *Lucernaria*, to which new species are now being added, not by the modification of the old one or ones, but by new "degenerations" of scyphomedusæ, or new "arrestments" of scyphistomata of various species of medusæ; and hence existing well-established species of *Lucernaria* (supposing there *are* such) may have arisen, not from a common ancestral form of *Lucernaria* at all, but by a series of separate "degenerations" of scyphomedusans through a *Haliclystus* stage. Or, on the other hand, it may be that *Lucernaria* and *Haliclystus* are only names for different forms of "monstrous" scyphomedusa, arrested in the scyphistoma stage—that is, arrested so far as strobilation is concerned, but developing the reproductive organs.

I would submit, therefore, the following conclusions for criticism:—

(1.) That *Haliclystus* is a degenerate or arrested scyphistoma (*cf.* axolotl!);

(2.) That its marginal bodies are *arrested rudiments* (*i.e.*, vestiges) of tentaculocysts;

(3.) That *Lucernaria* is a still further modified ("degenerate") descendant of some free-swimming medusæ of one or more species;

(4.) That the degeneration and disappearance of the tentaculocysts, when these ceased to be of use for the function I ascribed to them, supports the view I have expressed in a former essay on the subject of their function.

REFERENCE.

1. **Clark, H. J.**—Lucernariæ and their Allies. Smithsonian Contributions to Knowledge, vol. xxiii., 1881.

C. HERBERT HURST.

VII.

Notes on Pipernoid Structure of Igneous Rocks.

MOST geologists are acquainted with a peculiar rock, much employed as a building stone in Naples, that occurs near that town at a village called Pinaura, and known by the name of "Piperno." What the origin of this name may be, I do not pretend to know, but it much resembles the word *peperino*, a true though peculiar tuff, derived from a sub-lacustrine eruption of the Colli Albani, near Rome, but entirely different in character.

For all practical purposes, this rock may be called a rather basic trachyte, but not uniform in structure. It is of a clear grey colour, interrupted by innumerable flackers,[1] when seen in section lying parallel to the surface on which the rock bed rests. These, when isolated, are seen to be flattened cakes of an original pasty material, rather longer in one definite axis with striæ parallel to the same, and of such a nature as to show that shearing occurred in the viscous material between the upper and lower surface of each cake. Chemically and microscopically, these two constituents are identical, except that the black flackers, or cakes, are more compact, exhibit true fluxion structure in harmony with their planes of shearing, and are much more vitreous; in fact, they present all the characters of a lava. The grey material is very spongy, but does not present true vesicular structure, extending beyond the minute particles of which it is composed, and, in fact, exhibits all the characters of a tuff—that is, a consolidated volcanic dust.

Piperno occurs in one or more beds in the neighbourhood of Pianura, Soccava, and Monte Spina. Of late years I have paid much attention to this rock, and I have been successful in working out the stratigraphy and physical history in detail of the Phlegrean Fields and the Campanian plain. The principal conclusions that I have come to have been published in the Reports Brit. Assoc. since 1884. In these researches I was able to show that we could trace the piperno into the grey tuff which covers several hundreds of square miles of the

[1] This word is used by cabinet-makers to denote the markings due to the c utting the medullary rays in an oblique manner, which resemble the graining of piperno.

Campanian plain, and even remnants of which are found filling depressions in the limestone as far as Bari. This tuff much resembles the piperno, except that the grey interstitial matter gets finer and lighter the further we extend outwards radially from the true piperno. Coincident with this, we find that the blacker cakes become more and more spongy, not at first rapidly decreasing in size, but decreasing in bulk specific gravity. After a certain distance, we find they also decrease in size, until at distances of 20 to 30 kilometres they are almost invisible. The flattening out of the cakes, parallel to bedding, soon disappears as the black inclusions get lighter and more scoriaceous.

All geologists who have attempted to explain these *principal* peculiar characters, have utterly failed to do so, and had I space to enumerate many minor ones, the difficulty would be still greater. Unfortunately, most of these conclusions have been jumped at, as the result of that useful instrument though unfortunate misleader of geology, the microscope, which has caused investigators to forget that it is only one means to an end, and that field investigation is of far greater importance.

Some have supposed it to be a metamorphosed tuff, but I have shown that subjacent beds of pumice are as fresh almost as the day they fell; others, have imagined it metamorphosed by infiltration or some internal reaction; others, again, maintain it to be a lava. It was only after years of careful investigation that the true explanation suggested itself to me.

In my researches on the Geology of Monte Somma and Vesuvius,[2] I was able to bring forward conclusive evidence that the volcanic paste that occupied the duct of a volcano was nearly, if not entirely, vapour-free, and that it dissolved H_2O out of the upper stratum of aquiferous rocks of the earth crust. I showed that in any explosive eruption, the uppermost part of the paste in the canal was the most gaseous (H_2O), and that, as the eruption progressed, the pumice ejected became more compact, and cooled slower by a less conversion of its potential into kinetic heat for the evolution of less gaseous contents.

The Geological Society published my facts, refusing to do so with my conclusions, but the Royal Dublin Society was more charitable and put them before the public.[3] Those facts and conclusions have never been assailed, but have carefully been passed over by subsequent writers on volcanoes, although they are, I maintain, the only scientific and generally applicable explanation of volcanic action offered to the public—not a romantic hypothesis, but one borne out in every region I have yet examined.

Now, what appears to have occurred with the *piperno* eruption is

[2] *Q. J. Geol. Soc.*, 1884, vol. xl., pp. 35–112.

[3] *Q. J. Geol. Soc.*, 1885, vol. xli., pp. 103–106; and *Scientif. Proc. Roy. Dublin Soc.*, vol. v., n.s., pp. 112–156.

as follows: A trachytic paste occupied a volcanic duct towards the surface. During a considerable period of repose the upper portion absorbed much water, its temperature fell, and its tension rose in proportion; lower down, less change of this nature had taken place. When the final outburst occurred, the vent must have been of tremendous size, as proved by the enormous quantity of material ejected. In consequence, the lower part rose almost coincident with the upper, as shown by the arrangement of the deposit. The upper cooler, more aquiferous part, was soon reduced to a solid dust by vesiculation, and fell as such, while the hotter, lesser aquiferous, was only separated into cakes. The heaviest and most compact of these would fall amid the dust as hot masses, close to the vent where they would spread out by their own weight and by the pressure of other material that immediately buried them. They were squeezed out by a movement hardly amounting to flow, but just sufficient to elongate them where they rested on an inclined surface. The greater the inclination, the more are they pulled out, so that in the buttress under Camaldoli, which shows the bed fairly inclined, the flackers are reduced to that of the thinnest paper.

The top and bottom of each piperno bed are less compact, and have less of the enclosed flackers of lava, for very obvious reasons, too lengthy to detail here. Even in a single bed of piperno, the variation in size and numbers of the flackers varies greatly with the horizon, but such variations are continuous over considerable distances. These differences of structure really record the fluctuations in the force of the eruption and the temporary predominance of one or other of the two kinds of ejecta.

Near the vent little dust fell, because it reached great altitudes and was carried away by the wind. The heavier lava cakes, however, fell by preference near the vent, especially the more compact and heavier ones; more and more scoriaceous, and therefore lighter were they, the farther they travelled, and the colder were they when they fell, so that at a short distance they were too hard to flatten out. At still greater distances, however light and scoriaceous they were, the large, then smaller and smaller ones, fell, until finally the deposit is practically composed of the dusty part only.

The *piperno* at Pianura consists of several beds intercepted by brecciated fragments of trachyte of the same composition, which, no doubt, mark an interval during which a crust solidified, to be re-broken up by the fresh outburst that formed the next bed.

I have spoken of one vent, but I do not deny the possible existence of a long fissure that reached the surface at several points. Neither should I dare to attribute certain pipernoid tuffs, south of and near Rome, to the vent, or the main one if several, that opened between Monte Spina and Camaldoli. At Monte Spina the blobs of lava were so large and so slow in cooling that they actually flowed as a stream.

In Ischia, on the east coast of the island, is a lava in which two magmas seem to have issued and flowed together, almost reproducing that kind of structure of earthenware, of mottled design, made by working together different coloured clay. From that we pass to the banded trachytes of Palmarola and the so-called felsites (because they are old) of the neighbourhood of Dresden, or the liparites of Basiluzzo.

The vitreous crust of some of the flackers, the peculiar conformation around foreign enclosures, the nature of these latter, and many other points might be discussed as confirming this explanation. At any rate, I hope to have cleared up a knotty point in lithology by showing that my theory of volcanic action is able to explain even an intricate rock structure, such as that which I have called "pipernoid," from its remarkably perfect illustration in the *piperno*, and which I have frequently seen exhibited in rocks from Iceland to Sicily.

H. J. JOHNSTON-LAVIS.

VIII.

The Evolution of Life.[1]

PROFESSOR BROOKS has printed in advance from his memoir on the genus *Salpa*, chap. vii., on "Salpa in its Relation to the Evolution of Life," and chap. viii., on the "Origin of the Chordata considered in its Relation to Pelagic Influences." Salpa is distinctively a pelagic animal borne hither and thither on the surface of the ocean as currents and the wind direct, living entirely on the minute micro-organisms and, unlike so many of its nearest relations, spending no part of its life attached to rocks, or weeds, or mud. Professor Brooks has been studying its life-history and its structure minutely, and has come to some biological conclusions of very general interest, conclusions which, perhaps unnecessarily, he apologises for as heterodox; but we hope that morphology so far is free from the doctrine of authority. Its generalisations tread so closely on the heels of observed facts that, granted the necessary skill in manipulation, no morphologist need accept much on the authority of a memoir, or a text-book, that he cannot verify with the scalpel and microscope.

Dr. Brooks leads up to his results by consideration of the contrast between terrestrial life and marine life. The surface of the land is more or less completely covered by verdure. Forest trees, and herbs and grasses, ferns and mosses stretch their green expanses into the air, and the chlorophyll of the cells in the presence of sunlight is constantly building up from the inorganic elements of the earth and air rich supplies of protoplasmic food; and so on the surface of the earth the vegetable eater, as insect, or bird, or mammal, abounds not only in species but in individuals, while carnivorous forms are found in smaller numbers, and obviously in immediate dependence on the vegetarian world.

The ocean waste is very different. Here and there are floating tufts of sargassum, but save round the coasts the vegetable world is meagre, and the richly-coloured gardens of the bottom are nearly all animal forms. So, too, in the sea, the conspicuous animals are nearly all carnivorous. The seals live upon fish; the sea elephants and walruses on lamellibranchs; whales, dolphins, and porpoises

[1] STUDIES FROM THE BIOLOGICAL LABORATORY OF JOHNS HOPKINS UNIVERSITY, vol. v., No. 3. "Salpa in its Relation to the Evolution of Life." By Professor W. K. Brooks, Ph.D., Baltimore, May, 1893.

live upon sea animals. The enormous numbers of terns, gulls, petrels, cormorants, and so forth, are all carnivorous. Among lower forms, practically only a few molluscs, echinoderms, and annelids are plant-eaters, and they play an inconspicuous part in the economy of the ocean.

If a small amount of *débris* coming from the land is left out of count, the source of the food-supply of the ocean is to be found in the minute organisms of the surface. *Trichodesmium*, *Pyrocistis*, *Protococcus*, and the coccospheres, rhabdospheres, and diatoms form the lowest link in the chain. These and the globigerinæ and radiolarians that feed on them, are so abundant and prolific as to supply practically all the food for the animals of the ocean. Such a simple pelagic food-supply Dr. Brooks believes to be, not only the fundamental, but the primæval supply—the supply which has determined the course of evolution of marine life, and secondarily of all life. The conditions of pelagic life are so simple and so universal, that the dawn of life appeared there. There is no fierce competition, and very little stimulus for the production of diversity of habit. All the metazoa have pelagic larvæ, or else embryonic stages recalling such larvæ, and best interpreted as the degenerated vestiges of a pelagic habit. During the long period in the history of the earth when there was practically only pelagic life, the pelagic ancestors of the great groups of the metazoa were evolved.

These advanced little till multiplication in the number of individuals drove some to the bottom or to the shore. In the strain and stress of the new conditions with their more varied mutable environment, increase of size and complexity, appearance of shells and skeletons began. All this happened before the earliest fossiliferous strata, for these show abundance of complicated types, of which their minute primæval pelagic ancestors left no traces in the sedimentary rocks. Secondarily, a number of forms returned from the bottom to the surface just as the Cetacea and many sea-birds returned from the land to the sea, and the improved wanderers rapidly produced changes in their ancestral pelagic home; but none the less a number of surface forms Dr. Brooks believes to retain the simplest possible structure, and to resemble closely the primæval ancestors of their groups.

Among these are notably the ancestors of the Chordata. Dr. Brooks criticises very closely Dohrn's famous degeneration theory of the Ascidians and finds in *Appendicularia* a little modified ancestral pelagic chordate.

One difficulty in the way is the possible importance of metamerism; but Dr. Brooks makes light of this, and many morphologists will be ready to agree with him. Metameric segmentation is a feature which occurs in widely-separated groups: which appears again and again in cases where there can be no possibility of community of descent. It may, in fact, be said that metamerism is so characteristic of life that

it is more likely to disguise than to reveal kinships. Dr. Brooks considers it a corollary of growth by cell-reproduction, but to whatever biological cause it may be due, too much importance has been attached to it in the framing of phylogeny.

The ancestor of *Appendicularia* he pictures as a "simple, minute, unsegmented chordate animal, leading a free locomotor pelagic life, and subsisting on the micro-organisms of the ocean. It had an elongated, unsegmented body stiffened by an axial, unpaired, unsegmented notochord like that of *Amphioxus*, *Appendicularia*, and the ascidian larva: a simple elongated dorsal nervous system: and an elongated, ventral digestive tube without pharyngeal clefts." This tube was distended and ciliated, and the water with the micro-organisms in it was swept through by ciliary motion, not by contractions of the body-wall.

In process of time there came slime cells to retain the food, and Natural Selection preserved and accentuated the slime cells in the anterior region. The free current of water passing through the animal at first swept in new organisms, and swept even any partially digested organisms. However it might have appeared, a pharyngeal cleft that would allow this free stream of water to pass out, leaving behind the slime-bound food, would be an advantage too great not to be selected, and one gill cleft being established, Dr. Brooks believes that by a "law of growth" it would become paired.

Thus he finds in the primitive gill clefts mechanical advantages for nutrition quite unconnected with respiratory or excretory functions. The velum, the endostyle, and the peripharyngeal bands similarly were food-catching mechanisms.

He traces out stages by which fixed Ascidians might easily have been derived from a free-living form like *Appendicularia*.

In the next section Dr. Brooks criticises the Annelidan theory very closely; but we imagine that, however fertile they have been in suggestions, and full as they are of brilliant morphological detail, not many naturalists support the main thesis of Dr. Dohrn's well-known studies; and for that reason it is hardly necessary to refer in detail to the present criticism. Still less to the associated criticism of the hypothesis that the Tunicates are degenerate Selachians.

What is more interesting is the view Dr. Brooks takes of the coelome. Since Hertwig first insisted on the importance of this method of development of the body-cavity, it has been accepted as final that the chordate body-cavity is an enterocoele—that is to say, that it is developed from series of pairs of gut-pouches, and that the simplicity of *Appendicularia* cannot be primitive, as its ancestors once possessed a segmented enterocoele. Seeliger gives a minute account of the origin of the mesoderm in *Clavelina*, and states that it comes from two totally unsegmented rows of cells, while the body-cavity is really a primary segmentation cavity. Davidoff, working on *Distaplia*,

agrees with him, and Dr. Brooks, from the development of Salpa, coroborates both. Practically, his conclusion is that the Chordate ancestor came straight from a simple pelagic form of which *Appendicularia* is a near living kinsman. The relations between the Chordates and other groups are to be looked for only among the characters common to such simple pelagic forms, and all chimæras, like the Arachnid or Crustacean ancestry of the Chordates, are relegated to the same oblivion as the more useful, if not more satisfactory, Annelidan hypothesis. It must, however, be pointed out that while Dr. Brooks received Willey's new work on Ascidians and *Amphioxus* in time to criticise it sharply, he had apparently not received, and so has not yet tried to consider, the bearings of the newly-discovered nephridial organs of *Amphioxus*.

SOME NEW BOOKS.

BIRDS IN A VILLAGE. By W. H. Hudson, C.M.Z.S. 8vo. Pp. 232. London: Chapman and Hall, 1893. Price 7s. 6d.

WE congratulate Mr. Hudson upon the publication of this pleasant volume, which is sure to receive a hearty welcome from all who like graceful essays about country life. "Birds in a Village" contains nothing absolutely new to us, nor is it intended in any sense as an ornithological treatise. Its function is to convey to us in a singularly felicitous style the impressions which the author has gathered from his rambles beside English brooks and across our home commons. Therein Mr. Hudson has found an agreeable variation from city life. Accordingly, he introduces us to simple village folk, and interprets for us their thoughts and instincts; or sketches the picturesque details of local scenery, following out his observations with such obvious faithfulness of narrative that we seem to see with his eyes and to hear with his ears.

There is, it must be confessed, a large element of "twaddle" in these pages; but *that* is such a constant ingredient of "popular" books upon Natural History, that it would be absurd to quarrel with it. The general public will perhaps prefer it to the enunciation of scientific truth; if it does not do much good, assuredly it is impotent to do anyone an injury. We know that Mr. Hudson is at heart as devoted to scientific ornithology as could be desired, and that when he romances or tells a pretty fairy tale, it is only because he prefers to be amusing rather than to edify us. Slight as he admits his knowledge of English birds to be, his diffidence cannot conceal the fact that with many of our homely birds he is thoroughly familiar, and his descriptions of their idiosyncrasies are pleasant to glance over. Not that Mr. Hudson discovers new points in their life-history; but because, being perfectly in correspondence with his environment, he plays the part of a faithful interpreter of their emotions and sensations, whether occupied in studying the movements of a jay amid the leafy foliage of some quiet copse, or comparing the song of the hedgerow nightingale with the richer notes of the white-banded mocking bird of his native country. Mr. Hudson is always certain to enlist our sympathy in his patient study of the most commonplace incidents.

We differ from Mr. Hudson in one particular. We refer to his tirade against the supposed enormity of keeping song-birds in captivity. The most that he can say against this custom, which exists all the world over, is that Mr. Rennell Rodd has protested against the practice in the dainty verse which our representative at Zanzibar so well understands how to frame. We have ourselves derived a vast amount of pleasure from our caged pets, and having enjoyed in this way the friendship of such rare and interesting forest birds as the Nutcracker, or the Great Spotted Woodpecker, may here register our dissent from Mr. Hudson's perfervid sentiments.

H. A. MACPHERSON.

HANDBOOK OF PALÆONTOLOGY. [HANDBUCH DER PALÆONTOLOGIE.] By K. A. von Zittel. Vol. iv., pt. ii. Pp. 305–592. Munich and Leipsic: R. Oldenbourg, 1893. Price 10 marks 50 pf.

As briefly mentioned in our last number, where we gave a notice of the preliminary issue of the Introduction, this important work is now fast approaching completion, and we have the pleasure of welcoming the second fasciculus of the volume devoted to Mammals.

This part, which fully maintains the high standard of its predecessors, contains the greater portion of the Ungulates, which are concluded, together with the Rodents, Insectivores, Bats, and the commencement of the Creodont Carnivores. We are glad to observe that among the Ungulates special attention is devoted to the numerous South American forms which have been described of late years; and we may safely say that nowhere else can the student obtain so much information on a very difficult subject in a very short space. In regard to the arrangement of the Ungulates, the author, while following in the main the divisions into sub-orders adopted by most modern writers, makes a new departure in respect of the limits of families. He takes, for instance, the Suidæ to include genera so widely different from the typical forms as *Achænodon* and *Chæropotamus*, while the Anoplotheriidæ embraces the Cænotheres, Dichobunes, and Dichodons, and under the Cervidæ are ranged, not only the Deer, but likewise the Giraffes and Sivatheres. We confess that this arrangement is not to our liking, as it involves the introduction of a number of sub-family names; while the inclusion of the Giraffe and its allies in the same family as the Deer tends to obscure their manifest affinities in some respects with the Bovidæ. In discarding the sections Tragulinæ and Pecora, we are, however, persuaded that, from a palæontological standpoint, the author is correct, since, as we ourselves have previously urged, it is impossible to draw any line of demarcation between the Tertiary Deer and Chevrotains. That the Professor should have seen reason to employ family names in such a wide sense is the more surprising to us, seeing that among the Ungulates he splits up many groups, such as the Elephants, Oxen, and Uintatheres, into so-called genera, which it has been the tendency of modern writers to ignore. We are pleased to notice that the author fully confirms the view that the three-toed Eurytheriums of the Vaucluse Oligocene are not generically separated from the typical Anoplotheres of the Paris Basin; but we should like to be more fully assured that the latter were likewise tridactylate. So far, indeed, as the casts of Cuvier's typical specimens in the British Museum admit of forming a judgment, the Paris specimens certainly appear to have been didactylate; and an important difference in the form of the astragalus in the specimens from the two localities has been noticed by several writers. As a minor criticism, we may mention that we cannot assent to the inclusion of the Hartebeests in the same group as the Gemsbok and Sable antelope, the cheek-teeth of the two being so essentially different; while the writer of this notice may take the opportunity of disclaiming the position of sponsor to the genus *Helicophorus* assigned to him on page 418.

As the treatment of the other orders described in this fasciculus does not call for any special notice, we may conclude with the hope that we shall soon have the opportunity of congratulating the learned author and his able colleagues on the completion of their arduous and monumental task.

R. L.

CHEMICAL AND MICRO-MINERALOGICAL RESEARCHES ON THE UPPER CRETACEOUS ZONES OF THE SOUTH OF ENGLAND. By William Fraser Hume, D.Sc., etc. 8vo. Pp. 104. 3 Tables. London: [Printer—Whitehead, Morris & Co., 9 Fenchurch Street], 1893.

THIS publication is, we believe (though it is not so stated), the author's thesis for the degree of D.Sc. of London. It is the most interesting contribution that has appeared for some time on the Cretaceous rocks, and bears evidence of a vast amount of laborious and painstaking research. Commencing with the Chalk Marl, the author gives chemical and mineralogical analyses of the washings of samples of 80 grammes average weight of each of the zones of the Chalk, from the Chalk Marl to the *Belemnitella mucronata* zone, and also discusses the micro-zoological remains which occurred in the residues. The samples were mostly taken from the immediate neighbourhood of some distinctive fossil, so as to be typically characteristic of the zone to be examined. Each zone is treated separately and in detail, the chemical analysis coming first, then the organisms, thirdly, the secondary minerals, and, lastly, the detrital minerals.

The author has wisely taken into his confidence specialists in their own departments, and has thus not fallen into the fatal error of describing everything that came into his hands. Thus, Dr. Hinde has looked over the sponge spicules, and Mr. Chapman has examined the Foraminifera. Towards the end of the paper we find a summary of results, and here Dr. Hume discusses the secondary silicification of Foraminifera in a clear and exhaustive manner. He says, "there seems little reason to doubt that considerable replacement of the calcareous constituents by colloid silica has taken place," and he notes that the most delicate interior divisions are in a fine state of preservation, after the residue has been treated with acid. So complete has this replacement been in many cases that, in the process of solution by acid, the bubbles issue from the mouth only of these microscopic tests. Following these mineralogical notes, Dr. Hume mentions a comparative identity between the foraminiferal fauna of the Chalk Marl and the Gault, and commenting on the depths at which many forms live in recent seas, inclines to the view that the Chalk Marl was deposited at a depth of from 350–500 fathoms. No new light has been thrown by Dr. Hume's researches upon the distribution of the sponges in Cretaceous times, nor has he met with remains of Radiolaria or Diatomaceæ in the rock-specimens examined.

In the general summary devoted to mineralogy, the author notes the predominance of quartz in angular fragments, with occasional crystals, worn and clear, in the lower Cenomanian beds. Inclusions in quartz of apatite, rutile, tourmaline, ferruginous oxides, liquids, and gases are recorded, and other forms of silica, as jasper and chalcedony, have been detected. Felspar occurs in Chalk Marl at Folkestone and in certain of the Turonian and Senonian beds of other places, but it is much altered. Hornblende, augite, tourmaline (widely distributed), zircon, rutile, garnet, glauconite, limonite, and pyrite are also recorded in the paper. The glauconite abounds in the Chalk Marl, but rapidly diminishes in the higher Cenomanian. It reappears as an important constituent in the Chalk rock, and continues to form a considerable portion of the residue in all the lower Senonian zones. Preference is given to the theory, in accordance with Cayeux's views, that glauconite may be formed independently of the presence of organisms. According to the author's observations, the greater the thickness of the beds the more calcareous do they

become, and he does not accept Cayeux's view of the terrigenous origin of Chalk as applicable to the Chalk as a whole, but considers that "such evidence as is forthcoming from faunal considerations points to an ocean which, if not abysmal, at least possessed depths far exceeding those of many prominent marine areas."

Space prevents any further notice of this interesting contribution to Cretaceous history, the researches for which have been carried out in the laboratory of the Royal College of Science; and while congratulating Professor Judd on the success of his choice of demonstrators, we thank Dr. Hume for providing so much food for reflection to the students of oceanic deposits, micro-zoology, and geology.

LESSONS IN ELEMENTARY BIOLOGY. By T. Jeffery Parker, D.Sc., F.R.S. With 88 illustrations. Second Edition. London: Macmillan & Co., 1893. Price 10s. 6d.

PROFESSOR PARKER'S well-known text-book is designed for reading—a complement to laboratory work with a text-book like the "Practical Biology." It aims at teaching the ideas rather than the details of the science of Biology—these ideas being studied in connection with concrete types of animals and plants. It is hardly necessary to do more than welcome the second edition of a volume so familiar and so satisfactory. It has been revised; several new figures have been introduced; and the lessons dealing especially with cell-structure and sexual cells (vi. and xxiv.) have been practically re-written. It is hoped that the few notes now to be made will be taken, not as criticisms directed against the book, but as footnotes which may be of some use.

On page 7 Professor Parker writes that "the theory is that protoplasm has a slightly acid reaction." This is very doubtful; it is practically certain that the enchylema is slightly alkaline—and it is doubtful if there is acid reaction in living protoplasm except in the secretions in food vacuoles.

On page 16 the author distinguishes between "true excreta" and the solid excreta, or, "more correctly, *fæces*, of Amœba—the rejection of which latter is no more a process of excretion than the spitting out of a cherry-stone." But certainly the "fæces" of the higher animals are largely composed—not merely of undigested substances, but of matter actually excreted by the cells lining the digestive tract.

On page 21, where the author is discussing the effects of salt on Amœba, he conveys the impression, although he does not definitely assert, that Amœba is confined to fresh-water—whereas it is quite common along the shore.

In the section on Diatoms no mention is made of Bütschli's account of the cause of their movement. (See NATURAL SCIENCE, vol. i., p. 537.)

SUBTERRANEAN PICARDY [LA PICARDIE SOUTERRAINE. Album Composé de dix Planches en Chromolithographie reproduisant des Armes, Outils et autres Utensiles en Silex trouvés dans les Alluvions Quaternaires de la Vallée de la Somme (Époques Chelléene et Moustérienne). Dessinées et Lithographiées en couleur par M. Piiloy, officier d'Académie [etc.]; et imprimées par M. Bourbier, Rue Saint-Jacques, 9, Saint-Quentin.] 4to. Pp. 10, pls. x. Saint-Quentin: Poette, 1892.

UNDER this lengthy title we gladly chronicle a book of ten pages and ten plates, relating chiefly to flint implements. The text is very

brief, is dated May, 1892, and is mainly descriptive of the plates which follow. These plates are so remarkable in execution, and so true in colouring, that it is scarcely an exaggeration to say that they are as good as the implements themselves. The extraordinary markings, so familiar on broken flints, are here produced in a most perfect and striking manner; indeed, we had scarcely hoped that chromolithography had reached so high a degree of excellence. MM. Pilloy and Bourbier, for their names must be linked together in this beautiful production, have evidently worked for the love of their subject, and whether we regard these plates from the point of view of draughtsmanship or from that of artistic skill in printing, they have given us results of which they may be justly proud, and which, instead of being buried in our bookshelves, should rather find a place upon our walls.

REPUBLICATION OF CONRAD'S FOSSIL SHELLS OF THE TERTIARY FORMATIONS OF NORTH AMERICA. By Gilbert Dennison Harris. 8vo. Washington: May, 1893. Price 3 dols. (after November 1, 3.50 dols.)

CLOSELY following on Dr. Dall's collation of Conrad's works, Mr. Harris, who has devoted much time and labour to the collation of these rare publications, has issued an exact reprint of the text, and facsimile of the plates, of one of them. Mr. Harris was largely responsible for the facts in Dall's work, and has received full acknowledgment in the preface. Now that we are in possession of Conrad's paper, many doubtful points in the identification of species of American Tertiary fossils will be cleared up, and without entering into controversy as to the actual dates of publication of the parts of this work, we feel that the thanks of all palæontologists are due to Mr. Harris, in reproducing for us a book so rare, that it could only be compiled from fragmentary and incomplete copies of the original.

CATALOGUE OF SOUTH AUSTRALIAN MINERALS, with the Mines and other Localities where found; and brief remarks on the mode of occurrence of some of the principal metals and ores. By H. Y. L. Brown. 8vo. Pp. 36. Adelaide: 1893.

THIS Catalogue supplants that of Goyder issued in 1883, and is intended to supply miners, prospectors, and others, with a record of mineral discoveries for convenient reference. The author does not pretend that it is exhaustive, as many private collections which possibly contain minerals are unavailable. The Catalogue is arranged in alphabetical order, and in each case consists of the name of the mineral, followed by a list of the localities.

WE understand that Messrs. Cassell & Co. have resolved to discontinue the issue of the *Year Book of Science*. Only two annual volumes (1891, 1892) have been published.

OBITUARY.

JOHN RAE, F.R.S.

BORN 1813. DIED JULY, 1893.

AS briefly noticed last month, this veteran Arctic explorer has passed away. He was a native of the Orkneys, and at the age of 16 entered the medical school of the University of Edinburgh. In 1833 he was appointed surgeon on one of the vessels of the Hudson's Bay Company, and in 1846 he undertook an important survey of the North-east Coast of North America. Two years later Dr. Rae accompanied Sir John Richardson in searching for the missing Franklin expedition; and the next six years were occupied almost continually in exploring the Arctic regions. He first proved King William's Land to be an island, and his detailed surveys have placed him in the front rank of the pioneers in Arctic exploration. Besides numerous smaller memoirs, Dr. Rae published a "Narrative of an Expedition to the Shores of the Arctic Sea in 1846 and 1847" (1850) and in 1852 he was awarded the gold medal of the Royal Geographical Society.

JAMES WILLIAM DAVIS.

BORN APRIL 15, 1846. DIED JULY 21, 1893.

AS briefly announced last month, a sad breach has been made in the ranks of amateur naturalists by the death of Mr. James W. Davis, of Halifax, at the early age of 47. Born at Leeds in 1846, and educated at the local grammar school, he and a brother succeeded to the cloth-dyeing business of his father; and his active pursuit of scientific investigation was carried on only in such leisure as he could secure from business and from the numerous political, municipal, and educational movements in which he was a leading figure. The patronage of Art, Literature, and Science, and researches in Geology, Palæontology, and Archæology, formed Mr. Davis's means of recreation; and it is astonishing how much he was able to accomplish in the limited time at his command.

Though a prominent worker in the Yorkshire Societies from his earliest youth, Mr. Davis did not enter the scientific world as an original investigator until 1873, when he became a Fellow of the Geological Society and a member of the British Association. At

first he confined himself to the Geology of Yorkshire, and in 1878 he co-operated with the botanist, Mr. F. A. Lees, in publishing the well-known volume on "West Yorkshire." He had always felt especially interested in the fish-remains discovered in the Yorkshire Coal-measures, and on making the acquaintance of the late Earl of Enniskillen and Sir Philip Egerton, at the meeting of the British Association at Belfast in 1874, his attention was definitely directed to Fossil Ichthyology. He published many small papers, chiefly relating to the Carboniferous fishes, until 1883, when, at the suggestion of the Earl of Enniskillen, he began to contribute a series of large illustrated memoirs to the *Transactions of the Royal Dublin Society*. His first memoir dealt with the fossil teeth and spines of the Carboniferous limestone, chiefly based upon the Enniskillen collection. The second memoir related to Professor Lewis's great collection of Cretaceous fishes from Mount Lebanon. Subsequently there were memoirs on the Cretaceo-Tertiary Fish-remains of New Zealand and on the Cretaceous Fish-remains of Scandinavia; while only last year the first part of a contemplated series of memoirs on the Coal-measure Fishes of the British Islands appeared in the same form. It is a matter of profound regret that Mr. Davis's untimely death should thus abruptly end the work.

Mr. Davis, however, was not merely an indefatigable palæontologist—one who has left a permanent impression upon Fossil Ichthyology; he was also a keen man of business, whose advice was eagerly sought in all manner of scientific undertakings. He had travelled extensively, and was on intimate terms with the leading men of his time in many walks of life. His extensive knowledge of the world, his genial disposition, and his enthusiasm in watching the advancement of every department of learning, gave him a position in British Science that none but his intimate friends could estimate; and it may truly be said that the demise of so valued a patron and trusted an adviser is a great and almost irreparable loss.

GEORGE BROOK.

BORN 1857. DIED AUGUST 12, 1893.

THE death of Mr. Davis in the prime of life was an unexpected shock, but still sadder is the sudden demise of his intimate friend and fellow-Yorkshireman, Mr. George Brook. While out shooting on the moors in Northumberland on August 12, Mr. Brook was paralysed by sunstroke and died immediately, though just before apparently in the best of health. Mr. Brook was born at Huddersfield 36 years ago, and entered his father's well-known cotton manufactory in that town. His interest in scientific matters, however, soon estranged him from business, and he trained himself in scientific work until he became an accomplished zoologist. His earliest observations were made in a

private aquarium he established at home, and some of his results were issued in pamphlet form. In 1884 he was appointed Assistant-Naturalist under the Scottish Fishery Board, and in the next year he became Lecturer on Embryology in the University of Edinburgh—a position he held until his death. Mr. Brook's first great work was his memoir on the Antipatharian Corals, published in the "Challenger" Reports in 1890; and for the last three years he had been occupied in cataloguing the corals in the British Museum. The first part of this catalogue, a fine quarto volume, dealing with genus *Madrepora*, and exquisitely illustrated with Mr. Brook's own photographs, has only just been issued. Now, alas! the work is suspended, and must be relegated to other hands. Mr. Brook was a member of Council of the Linnean Society, and the loss of his genial presence will be mourned by a large circle of friends.

GEORGE WILLIAM SHRUBSOLE.

BORN 1827. DIED JULY 22, 1893.

CHESTER has lost a valued citizen, and Science an enthusiastic worker, in the person of Mr. G. W. Shrubsole, F.G.S., the geologist and antiquary. He belonged to the Kentish family of the same name, being a brother of the well-known geologists, Messrs. W. H. and O. A. Shrubsole, and settled in Chester some forty years ago. Commencing as a chemist's assistant, in the course of a few years he started a business of his own in Market Square, which is now in the hands of his two sons. In addition to his retail trade, he had a considerable connection as an analytical chemist among mine-owners in North Wales. He was Honorary Curator to the Grosvenor Museum, a member of the Chester Archæological Society, and a painstaking student of the antiquities of his own city. Mr. Shrubsole was one of the founders, with Charles Kingsley, of the Chester Society of Natural Science, and held the office of Chairman of the Geological Section for some years. He contributed numerous papers on local matters to the Chester societies, and published a handbook to Chester antiquities on the occasion of the visit of the British Archæological Association. In 1879 and 1880 he contributed papers on the Carboniferous Polyzoa to the *Quarterly Journal of the Geological Society of London*, and in 1883 was awarded the Kingsley Medal of the Chester Society of Natural Science in recognition of the value of his researches.

MAXIMILIAN VON HANTKEN.

GEOLOGY in Hungary has sustained a loss by the death last June of Maximilian von Hantken von Prudnick. This venerable naturalist was Professor of Palæontology in the University of Budapest, Director of the Hungarian Geological Society, and a

Counsellor of the Hungarian Ministry, his chief care being, we believe, that of Education. V. Hantken's chief work was "A Magyar Korona országainak széntepelei és szénbányászata," 1878, a translation of which appeared about the same time in German as "Die Kohlenflötze und der Kohlenbergbau in den Ländern der Ungarischen Krone." He was the author of many papers on the Tertiary beds of his country, and paid special attention to the Foraminifera and Ostracoda therein contained: his papers on the former group occupying two and a half pages of Sherborn's "Bibliography." His "Clavulina Szabói regetck Faunája," with its sixteen beautiful plates, was really a monograph on the Foraminifera of this horizon, and his studies on the Nummulites have been of considerable value to others working in the same field. V. Hantken visited this country for the last time on the occasion of the International Geological Congress, 1888, when his amiability, courtly polish, and enthusiasm endeared him to many friends.

WE also have to record the death, at the advanced age of 87, of Miss ANNE PRATT (Mrs. Pearless), authoress of the well-known "Flowering Plants and Ferns of Great Britain." Miss Pratt's first work on "Flowers and their Associations" appeared in 1826, and she published many small volumes on Natural History, chiefly Botany. She revised the last edition of her "Flowering Plants" so recently as 1880.

THE deaths are announced of the geologists, GEORGE ROBERT VINE and D. HOMFRAY, the former well known for his researches on fossil Polyzoa, the latter a successful collector of Cambro-Silurian fossils in Wales; also of the Norwegian bryologist, FANTZ C. KIAER.

NEWS OF UNIVERSITIES, MUSEUMS, AND SOCIETIES.

We accidentally overlooked the name of Mr. William Fraser Hume in the list of successful candidates for the degree of D.Sc. in the University of London this year. We review Mr. Hume's thesis elsewhere.

The honorary degree of Ph.D. has been conferred upon Mr. Arthur Gardiner Butler, Assistant-Keeper of the Department of Zoology in the British Museum, by the Western University of Pennsylvania, U.S.A.

Dr. E. P. Ramsay, the curator of the Australian Museum, Sydney, is at present incapacitated for work, and is not expected to return for three months. During his absence the duties of the post are being performed by Mr. R. Etheridge, Junior.

Mr. T. D. A. Cockerell, whose resignation of the Curatorship of the Jamaica Museum we noticed some months ago, has been appointed Professor of Entomology, Zoology, and Physiology in the New Mexico Agricultural College, Las Cruces, New Mexico, U.S.A.

Professor W. J. Sollas has been appointed on the Geological Survey of Ireland, to carry on the petrological work, in the room of Mr. W. W. Watts, who has been transferred to the Geological Survey department in London. Mr. Watts now continues the examination and description of the Volcanic rocks of Great Britain.

Dr. A. Dendy, who has for the last four years been assistant to Professor W. B. Spencer at Melbourne, has recently been appointed Professor of Biology in Canterbury College, New Zealand. At present, during Professor Spencer's visit to England, Dr. Dendy is taking charge of all the biological work at Melbourne University, but after February next his address will be Christchurch, N.Z.

Mr. D. T. Macdougal, assistant in Botany at Purdue University, has been appointed instructor in Plant Physiology at the University of Minnesota. Mis Alice Eastwood has succeeded Mrs. Katherine Brandegree as curator of the Herbarium of the California Academy of Sciences and as acting editor of *Zoe*. Dr. J. M. Coulter, one of the editors of the *Botanical Gazette*, has left the Indiana University to become President of Lake Forest University, Illinois, and has taken with him his large herbarium, of which Mr. E. Uline has been appointed curator. Dr. Hans Schinz has been appointed to succeed Dr. Cramer as Director of the Botanic Gardens at Zurich; and Dr. F. Kaunhowen becomes Assistant in the Section of Fossil Botany in the Royal Prussian Geological Survey, Berlin.

THE Smithsonian Institution has secured a table at the Naples Zoological Station for the use of American investigators, in response to a memorial signed by nearly 200 working biologists.

ACCORDING to *Erythea*, Messrs Sandberg and Leiberg are at present engaged, under the auspices of the Department of Agriculture at Washington, in botanical exploration on the Columbia plains. The late summer and early autumn they expect to give to the eastern slope of the Cascades and the desert plains beyond. Mr. John Macoun is devoting the season of 1893 to the botany of Vancouver Island.

WE understand that a new zoological quarterly will shortly be issued by the Tring Museum, containing memoirs on Mr. Rothschild's collections, partly by himself and his curators, partly by other specialists.

A NEW part of the "Notes from the Leyden Museum" (vol. xv., no. 3, July, 1893) has been issued. The contributions are technical papers on systematic zoology, the only one of general interest being a Comparative List of the Birds of Holland and England, by F. E. Blaauw. It appears that Holland is the regular home or resort of 221 species of birds, while the larger area of the British Isles has only 211 species —of course excluding casual visitors.

THE collection of Italian fossils made by the late Baron A. de Zigno, of Padua, has been acquired by the University of that city. It comprises many type-specimens of Vertebrata described in the Baron's memoirs, and will form an important addition to the fine Geological Museum in the University building.

A NEW hall has just been opened at the Industrial and Art Museum of Melbourne. It is a fine large room, with a wide gallery running round, and is lighted by sky-lights. It is devoted chiefly to Practical Geology and Mining, and, besides containing numerous models and examples of mining machinery, has a fine collection of rocks and minerals, at present being excellently arranged by Mr. Walcott.

OWING to the prevailing depression the public scientific institutions of Australia are in a bad way. The vote for the Australian Museum, Sydney, has been reduced by a half, which involves the dismissal of over a third of the staff, and considerable lessening of the salaries of those who remain. A large new hall has recently been built at this Museum, chiefly for the reception of the geological collections. It is, however, impossible to exhibit the specimens, as no money is forthcoming to provide fittings for the cases.

SIMILAR tales of woe reach us from other places. The collections of the Queensland Geological Survey were only a year ago moved from Townsville to Brisbane, where they have been displayed in appropriate quarters by Mr. Jack and his assistants, Messrs. Rands and Maitland. Now, since the Government can no longer pay the rent for the building, they must be shifted into rooms of little more than half the size.

THE Ethnological Collection belonging to the Museum at Auckland, N.Z., has recently been moved into a new hall, where it has been admirably arranged by the curator, Mr. T. F. Cheeseman, F.L.S., who has drawn up and printed very useful descriptive labels. The collection is especially rich in Maori curios, but contains also many valuable specimens from the South Sea Islands.

THE American Museum of Natural History has despatched another expedition this summer to the western territories for the discovery of fossil mammalia. This is the third annual expedition of the kind, and the Museum is already beginning to exhibit a remarkable collection as the result of Dr. J. L. Wortman's former explorations. In 1891 only a small collection was made in the Wahsatch beds of the Big Horn Mountains. In 1892 the Puerco Eocene formations of New Mexico, the White River Miocene of South Dakota, and the Cretaceous Laramie rocks were examined. About five hundred specimens were obtained from the first-mentioned horizon, many fine fossils were discovered in the Miocene, and a very large collection of the minute mammalian teeth was made in the Laramie. The recent writings of Professor H. F. Osborn give some idea of the value of the investigation, on which the American Museum is to be congratulated.

A NEW scientific society, named the "Società tra i cultori delle Scienze mediche e naturali in Sardegna," has been founded at Cagliari, Sardinia.

THE new Malacological Society of London has decided to issue Proceedings at undetermined intervals. The publication will be edited by Mr. B. B. Woodward, and the first part may be expected shortly.

WE are glad to observe that the "Société belge de Géologie" has now succeeded in bringing its *Bulletin* up to date. Two parts have lately appeared, the one completing the volume for 1892, the other being the first part for the current year, The Treasurer is able to report that the deficit, which for several years has crippled the Society, is steadily disappearing, and that the year 1892 showed a small surplus.

THE Bristol Naturalists' Society has issued a new part of its *Proceedings* (n.s. vol. vii., pt. ii., 1892–93), containing several papers of much value in reference to the Bristol district. There are records of Phenological and Meteorological observations, Mr. A. J. Heath and Professor Lloyd Morgan publish a concise account of the fossil fish-teeth and spines found in the Carboniferous Limestone, with some original observations; Dr. A. R. Prowse discusses the ancient British remains on Clifton Down, with a map; and Mr. C. Druitt has an interesting original paper on the Green Woodpecker, based on his own observations in the neighbourhood.

THE Croydon Microscopical Club has just issued its *Proceedings and Transactions* for Feb., 1892–June, 1893. The most original paper is that of Mr. Murton Holmes, who discusses "The Microscopical Structure of Hearthstone from Detchworth, Surrey." Foraminifera and casts of the same in glauconite, sponge spicules, coccoliths and rhabdoliths, are recorded, with abundant scales of mica. It is gratifying to learn that the loss on the last soirée was only £10; for the Croydon Club soirées are excellent as a rule, both in exhibitions and arrangement.

CORRESPONDENCE.

Phylogeny *v.* Ontogeny.

A chance has enabled me to see Dr. Hurst's reply to my article on "The Recapitulation Theory in Palæontology." Without reference to his original paper it is impossible for me adequately to examine his argument; but, that I may not be thought to ignore his defence, I venture to send these lines.

I am not so sure that I have misunderstood Dr. Hurst's position, despite his assertion that none of my missiles hit it. At any rate, it is clear enough now: he does not deny that, in many cases, individual development may follow the same lines as the evolution of the race; he merely denies that the past history of its race has any influence on the growth-stages of an individual. Considering the impossibility of producing experimental evidence, such a position is, in strict logic, impregnable. For, let us suppose that the ontogeny of every individual was an epitome of its phylogeny, it would still be open to anyone to deny any *causal* relation between the two. But, if I remember rightly, Mr. Hurst, in his original paper, maintained that the development of any individual was a regular progress from the embryo to the adult; modifications of early stages, adaptations to larval environment, might of course occur, but, on the whole, each growth-stage represented an approximation to the adult. Consequently, when race-history consisted in a regular advance from the primitive ancestor to the specialised descendant, then the individual development must normally repeat it; ontogeny and phylogeny would necessarily move in the same direction along parallel lines, but there would be no need to suppose any causal relation. But if the history of a race were no such regular advance; if, on the contrary, it could be clearly shown by the evidence of fossils that the race had ascended to an acme and then descended; if a structure could be seen to appear and disappear during this history; then it is equally clear that, on Mr. Hurst's hypothesis, ontogeny would not correspond with phylogeny; it is clear that vanished structures or forms would not temporarily make their appearance during the growth of an individual, unless indeed they were produced by some other cause, as adaptations to a temporary environment. This appeared to me to be Mr. Hurst's position, and the following was the nature of my attack. I adduced instances of structures or forms appearing in the earlier stages of individual development, and then disappearing; these characters were not such as could be supposed due to larval adaptation or to any modifying causes of a temporary nature; but these characters could be shown by palæontological evidence to have arisen and disappeared in just the same way in the history of the race. Now, I will merely ask Mr. Hurst to tell me what cause can have produced these deviations of ontogeny from the path of simple development. Unless some plausible explanation can be found, it seems reasonable to suppose that they are due to heredity, and are, in fact, as well as seeming, recapitulations of ancestral history. In Mr. Hurst's reply I see no attempt to meet these difficulties. He merely denies that difficulties exist, and asserts that my shots have all passed by him. Despite his explanations it seems to me that the only reason he has not felt my attack is, because he is encased in some bullet-proof cloth or other, which has a little dulled his perceptions.

It is needless to reply to Mr. Hurst's other remarks while the above question remains unanswered. Only with regard to the figures illustrating the ontogeny and phylogeny of *Antedon* which he suggests should accompany a fuller account in a

future number of NATURAL SCIENCE, it seems enough to refer those interested to the classical description by Dr. W. B. Carpenter (*Phil. Trans.*, 1879), and to the second of my own papers on British Fossil Crinoids (*Ann. Mag. Nat. Hist.*, 1890).

Townsville, Queensland, F. A. BATHER.
20 June, 1893.

"RECAPITULATION" AND "EARLIER INHERITANCE."

IN reply to Mr. Buckman's remarks on pp. 138 and 139, let me beg him to be more careful in future.

I have never expressed any opinion whatever as to what views he had adopted either "as creeds" or otherwise, nor as to the nature of the "inspiration" under which he has written, and I have not either on p. 198 (vol. ii.) or elsewhere denied that there is "any" causal relation between ontogeny and phylogeny. P. 197 (vol. ii.) treats, as there distinctly stated, not of changes in individuals but of changes "in average constitution of successive generations" leading to production of new species. The word "structure" was used deliberately on p. 197 (vol. ii.), and in its strictest sense. I did not mean "character," I meant that complex abstract quality made up of *all* the characters together.

The "law of earlier inheritance" is on a par with the law of the north wind. Because characters are in *rare and exceptional cases* (*see* Darwin, "Origin," 6th edition, p. 10) "inherited" earlier in the offspring than in the parent, are we to have a "law" enunciated to the effect that the rare and exceptional is not rare or exceptional but universal? The "law" of the north wind states that all winds at all times and in all places blow from the north. Many authors might be quoted to prove that a north wind had occasionally been observed in some places. The "law" stands on as good a basis as does that of "earlier inheritance."

I used the term "late stages of development" believing that it would be clear from the context that I meant stages which, though late relatively, are passed through before the adult stages are reached.

The "contention" concerning loss of teeth and other senile changes does not affect me. It is at most a matter of words, and probably everybody agrees with both Mr. Buckman and myself that the words may properly be used in the way he has "contended" for.

By "acceleration of development" I mean a change in the average constitution of successive generations of a species by virtue of which the descendants of to-day pass more rapidly through some or all of their ontogenetic changes than did their ancestors. Is another meaning for the term in use?

Physiologically, of course, the term is applied to the shortening of the period of development by the artificial application of heat, etc., *e.g.*, in Weismann's experiments upon seasonal dimorphism ("Studies in the Theory of Descent," vol. i., p. 120, last paragraph).

I regret that the *Proc. Cotteswold Nat. Soc.* are not accessible to me, and I have therefore not read Mr. Buckman's "Some Laws of Heredity." I hope I may yet have an opportunity of doing so.

C. HERBERT HURST.

THE CLASSIFICATION OF ARACHNIDS.

IN a paper on some recent memoirs on "The Classification of Arachnids," by Mr. G. H. Carpenter (NATURAL SCIENCE, no. 16, June, 1893), it seems to me that the author has sadly neglected the work of at least one writer on the same subject; leading the unwary reader, if I am not mistaken, to conclude that many of the theories mentioned in that review are novelties brought forth for the first time, within the last year or two, by Mr. Pocock, whereas they are really the views published twelve years ago by Professor E. Ray Lankester in a classical paper not even mentioned, namely "Limulus an Arachnid" (*Quart. Journ. Micr. Sci.*, vol. xxi., 1881).

Now, I venture to think that in a review of that kind, intended presumably to be read by students and others not intimately acquainted with the literature of the

subject, the greatest care should be taken to avoid conveying, by implication or by direct statement, an erroneous idea as to who was the discoverer of any new fact of importance or the originator of a theory. For instance (I am speaking, of course, of the review, and not of Mr. Pocock's valuable paper), it is stated, page 448, that "On these grounds he [Pocock] considers the scorpions as the lowest living branch of the arachnid stem, in opposition to the views of Thorell and others, who have regarded them as the highest. There can be no doubt that Pocock's opinion will meet with general acceptance among biologists. Deriving the arachnid orders immediately from an ancestor with a long abdomen of twelve segments and a telson, Pocock indicates the modifications which have probably occurred in each group . . . nearly related to the Pedipalpi . . . are the Solifugæ . . . , on a higher branch . . . come the harvest men (Phalangida) . . , from these the mites (Acari) . . . a degraded offshoot." Turning to Lankester (*loc. cit.*, p. 644) we find, "the Scorpions, having once been developed, appear to have given rise to the whole series of living Arachnida, to the Pedipalpi first, and through these to the Araneina, and through the Araneina to the Acarina . . . we have to admit a very extensive process of degeneration . . . leading from the Scorpion to such Acarina as Demodeæ . . ."

In the discussion (p. 450) on the light thrown by palæontology "upon the question whether the lung-bearing or tracheate orders of arachnids are the more primitive," no notice whatever is taken of the mass of evidence collected by Professor Lankester showing the relationship between the Scorpions and the extinct Eurypterina and Trilobita.

On page 449, we are led to believe that Mr. H. M. Bernard originated the view that the "spinning-glands, coxal glands, and poison-glands" were derived from the "ventral setiparous glands of an annelid ancestor," a theory put forth by Eisig in his famous Monograph of the Capitellidæ.

The Museum, Oxford. E. S. GOODRICH.

"UNILATERAL" SLEEP IN ANIMALS.

THE late Sir Emerson Tennent, in his "Natural History of Ceylon" (1861) at page 279 observed that each eye of the Chameleon *(Chameleo vulgaris*, Daud.) had not only a separate action quite independent of the other eye, but that also one side of its body appeared sometimes to be asleep while the other side was vigilant and active.

Hence, while one side of the Chameleon was green, the other was red.

It is said that the Chameleon is unable to swim because the muscles of its two sides cannot act in concert. Is this true?

Similarly some other accurate observers, including Matthias Dunn of Mevagissey, suspect that certain fish can secure partial sleep with one eye at a time.

I should be grateful for further information and references as to whether other animals have been observed in this alleged condition of one-sided sleep while the other side of their body continues awake.

30 Sussex Square, Brighton. J. LAWRENCE HAMILTON, M.R.C.S.

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